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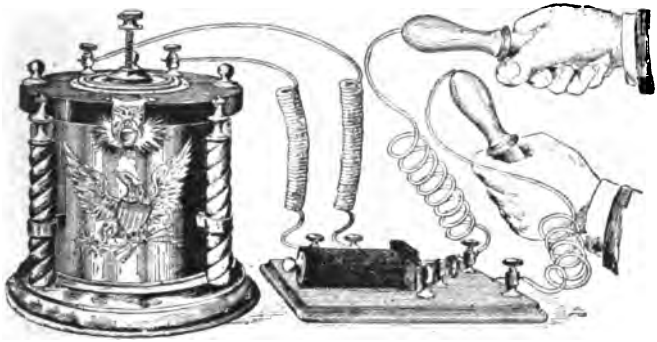

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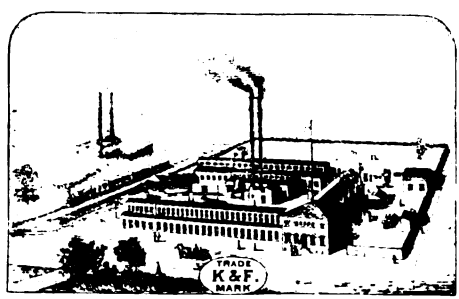


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THE

# SCHOOL OF MINES QUARTERLY.

VOL. XIII. NOVEMBER, 1891. No. 1.

## THE INTER-CONTINENTAL RAILWAY.

BY C. F. PARRAGA.

DURING the sessions of the Pan-American Congress, held in Washington, in the year 1889, one of the many important topics taken up for discussion was that of an Inter-continental railroad, which should unite by a continuous line all the nations of the American continents. For this purpose a committee was appointed to carefully study the subject, and as the result of its extensive report the following recommendations were adopted:

The International American Conference is of the opinion:

*First.* That a railroad connecting all, or a majority, of the nations represented in this conference will contribute greatly to the development of cordial relations between said nations, and the growth of their material interests.

*Second.* That the best method of facilitating its execution is the appointment of an international commission of engineers to ascertain the possible routes, to determine their true length, to estimate the cost of each, and to compare their respective advantages.

*Third.* That the said commission should consist of a body of engineers of whom each nation should appoint three, and which should have authority to divide into sub-commissions, and appoint as many other engineers and employés as may be considered necessary for the more rapid execution of the work.

*Fourth.* That each of the governments accepting may appoint,



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at its own expense, commissioners or engineers to serve as auxiliaries to the sub-commissions charged with the sectional surveys of the line.

*Fifth.* That the railroad, in so far as the common interests will permit, should connect the principal cities lying in the vicinity of its route.

*Sixth.* That if the general direction of the line cannot be altered without great inconvenience, for the purpose mentioned in the preceding article, branch lines should be surveyed to connect those cities with the main line.

*Seventh.* That for the purpose of reducing the cost of the enterprise, the existing railways should be utilized as far as is practicable and compatible with the route and conditions of the continental railroad.

*Eighth.* That in case the results of the survey demonstrate the practicability and advisability of the railroad, proposals for the construction, either of the whole line or sections thereof, should be solicited.

*Ninth.* That the construction, management, and operation of the line should be at the expense of the concessionaires, or of the persons to whom they sublet the work, or transfer their rights, with all due formalities, the consent of the respective governments being first obtained.

*Tenth.* That all materials necessary for the construction and operation of the railroad should be exempt from import duties, subject to such regulations as may be necessary to prevent the abuse of this privilege.

*Eleventh.* That all personal and real property of the railroad employed in its construction and operation, should be exempt from all taxation, either national, provincial (State), or municipal.

*Twelfth.* That the execution of a work of such magnitude deserves to be further encouraged by subsidies, grants of land, or guaranties of a minimum of interest.

*Thirteenth.* That the salaries of the commission, as well as the expense incident to the preliminary and final surveys, should be assumed by all the nations accepting, in proportion to population according to the latest official census, or, in the absence of a census, by agreement between their several governments.

*Fourteenth.* That the railroad should be declared forever neutral for the purpose of securing freedom of traffic.

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*Fifteenth.* That the approval of the surveys, the terms of the proposals, the protection of the concessionaires, the inspection of the work, the legislation affecting it, the neutrality of the road, and the free passage of merchandise in transit, should be (in the event contemplated by article eighth) the subject of special agreement between all the nations interested.

*Sixteenth.* That as soon as the government of the United States shall receive notice of the acceptance of these recommendations by the other governments, it shall invite them to appoint the commission of engineers referred to in the second article, in order that it may meet in the city of Washington at the earliest possible date.

In accordance with these recommendations, the Government of the United States invited the various American nations to appoint engineer commissioners and to meet in Washington. This was done by the majority of nations, and the Commission was organized on the 4th of December, 1890, with Mr. A. J. Cassatt, representing the United States, as president of the Commission.

The Commission was divided into committees to study the many subjects connected with an enterprise of such magnitude. The principal topics studied by the Commission were: The line to be chosen for study in the field that would best fulfill the general conditions as expressed in the foregoing recommendations, and at the same time serve the best interests of each and every country, and of the capital that will be invested in the enterprise; the organization, equipment and dispatching of the necessary expeditions to survey the line chosen, and to gather the data needed to demonstrate the practicability of the road.

The general route was chosen and analyzed as follows, taking in consideration that whenever possible the existing lines are to be utilized, which is done in the whole of the section of the United States and Mexico, whose line is practically completed to the frontiers of Guatemala:

## UNITED STATES AND MEXICO.

The existing railways in Mexico connect the railway system of the United States with the City of Mexico. A line of railroad is projected and has been surveyed from the City of Mexico to Ayutla, on the frontier of Guatemala. The city of Ayutla has, therefore, been selected as the point from which to start the surveys southward.

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GUATEMALA.

From Ayutla the line will run parallel to the Pacific coast, through Retalhuleu and Mezatenango to Santa Lucia; thence a branch of the Guatemala Central Railroad to Escuintla, now under construction, will be taken advantage of, and passing by Cujinijilapa the line will be continued to Sta. Anna, in the Republic of Salvador.

SALVADOR.

In this country the projected line of the Central R. R. will be utilized. It runs from the city of Sta. Anna to Nuevo San Salvador, San Salvador, and through San Vicente, San Miguel, to Guascoran, in the Republic of Honduras.

HONDURAS.

From Guascoran the line will continue along the shore of the Gulf of Fonseca, crossing the State of Choluteca to the city of the same name, whence it will run south to Nicaragua.

NICARAGUA.

From the northern frontier of Nicaragua the line will run to the city of Chinandegua, where it will connect with the railroad from Corinto to Lake Managua, following this railroad to the neighborhood of Pueblo Viejo; it will run along the shore of the lake to the city of Managua, where it will connect with the line already constructed between that city and Masaya. From this city it will run to Rivas, crossing the projected Nicaragua canal and entering Costa Rica.

COSTA RICA.

In Costa Rica it will run along the shore of Lake Nicaragua, across the plains of Guatuscos and San Carlos to the city of Alajuela, where it will connect with a branch road already constructed to the capital. From Alajuela it will follow the railroad of San José to Pto. Limon, and extend down the Isthmus of Panama to the valley of the Atrato, in Colombia.

COLOMBIA.

In Colombia the line will cross the western cordillera of the Andes to the valley of the Cauca, and follow this valley to Antio-

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quia. It will continue to ascend this rich valley, connecting its numerous cities and towns, until it reaches its head at Popayan. A branch line will be surveyed across the Central cordillera to the city of Bogota, and another from Antioquia, down the Cauca river, to the city of Cartagena, on the Caribbean sea, and one of the finest seaports in South America. From Popayan the main line will cross into the valley of the Patia to Pasto, and continue on to Ipiales and into Ecuador.

The crossing of the mountains from Popayan to Pasto is one of the most difficult problems which the engineers will have to solve. Here it is that all the three great ramifications of the northern Andes have their origin.

### Ecuador.

Entering Ecuador the line will reach the city of Tulcan; thence descending the central valley of Quito, it will next pass by the cities of Ibarra, Quito, Tucumbá, Ambalá, Cuenca and Loja, into Peru.

### Peru.

In this country the line, passing through the provinces of Cojamarca or Amazonas, will be carried on to the river Maranon, and through its valley to Cerro-de-Pazco, thence along the river Perene to Sta. Anna, thence to Cuzco, Sta. Rosa and Puno, and along the shore of Lake Titicaca to the Bolivian frontier.

### Bolivia.

In Bolivia the line will pass through the cities of La Paz, Oruro, to Huanchaca. From Huanchaca, Chile, the Argentine Republic, Brazil, Paraguay and Uraguay will be reached by branch lines.

### Chile.

A line of railway now in operation extends from Huanchaca to Antofagasta, on the Pacific coast.

### Argentine Republic.

A line of railway is projected and has been surveyed from Huanchaca to Jujuy, where connection is made with the extensive railway system of the Argentine Republic.

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### Paraguay and Uruguay.

A branch to connect these two countries with the trunk line will be run from Huanchaca along the west shore of the river Pilcomayo to a connection with the railway projected under the Osborne concession, which covers a line from the northern boundary of Paraguay to Asuncion. From Asuncion the line will go to Villa Encarnacion, crossing the Rio Parana opposite the city of Posadas, joining the Argentine R.R., now in construction to Monte Caseros. It will cross at this point the river Uruguay, to connect with the line, already constructed and operated, from Santa Rosa to Montevideo, which connects with the principal cities of the interior.

### Brazil.

To connect with the United States of Brazil, a line will be run from Huanchaca eastward across the river Paraguay, at Corumba, into Brazilian territory and along the river Toquary to Coxim. From this point a railway is projected to Uberaba, under a concession from the government of Brazil. From Uberaba to Rio Janeiro a railroad is now in operation.

### Venezuela.

This country will be connected with the trunk line by a branch from the most convenient point in the Cauca Valley to Medellin, whence it will connect with an existing railroad to the city of Pto. Berrio, on the Magdalena river; thence the route will be via Bucaramanga to San José de Cucuta; thence to San Cristobal, La Grita, Merida, Trujillo, Barquisimeto, and Valencia.

The Commission considered that the principal object of the projected Inter-continental Railroad is to unite all South American countries, and to connect, directly or indirectly, the capitals and principal cities—serving, at the same time, their political and commercial interests, without losing sight of the fact that the enteprise will have to be carried out in a great measure by private capital. Much data was collected regarding the different countries, but the regions through which it is proposed to run the line being in many parts unexplored, the information obtained has been very deficient.

The intention of the Commission was merely to choose a general route, to be followed in making the preliminary surveys;

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when these shall have been completed, a more definite location of the line can be undertaken. In selecting the general route the Commission has tried to take advantage of lines already constructed, under construction, and projected.

Three lines could be followed in Central, as well as in South America, viz.:

First. The western, between the Andes and the Pacific ocean.

Second. The central, or through the Cordilleras, and generally at great altitudes.

Third. The eastern line, between the Andes and the Atlantic, where the territory is much more extended, especially in South America.

All these routes have advantages and disadvantages.

Aside from the Isthmus of Panama, a narrow stretch of difficult country, with very little choice of general route, the remainder of the line naturally divides itself into two sections—each can be studied independently of the other—viz., the Central and the South American.

## Central America.

The line by the Atlantic coast presents a much less broken territory, and, in this respect, of easier construction. On the other hand there would be a number of large rivers to cross, and the territory traversed is sparsely populated and undeveloped.

On the eastern coast, too, the rains are frequent and torrential during the greater part of the year, and the climate is unhealthy. Another objection to the eastern line is that it could not touch the rich and important republic of Salvador.

A central line would have to be carried at great altitudes, through a volcanic region, much broken, very sparsely inhabited, and unproductive.

The third route extends along the Pacific coast, and appears to be the most advantageous one, as far south, at least, as the republic of Costa Rica. The country on this line is healthier and more productive. Nearly the entire agricultural industry is on the Pacific ocean side of the countries.

Entering into Guatemala it will pass through the centre of its coffee plantations, and will approach the principal cities of that country. Thence it will traverse the republic of Salvador, reaching its agricultural centres and its important populations. On this route,

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also, the survey already made of the Central railroad in that country can be utilized.

In Honduras the route follows the Gulf of Fonseca, and by a short branch connects the capital with the principal commercial and industrial centres.

The same advantages exist in Nicaragua, where the constructed railroads can be made use of. On account of the topography of the country it would be advantageous to abandon this route in the vicinity of Lake Nicaragua, and to enter into Costa Rica by the central plains.

These plains are covered with forests of great value, producing cocoa, rubber, rare timbers, etc., etc., in abundance. Moreover, in following this direction the line approaches the projected railroad from the capital to Lake Nicaragua, and would connect at Alajuela with the Inter-Oceanic Railroad, from Porto Limon to Punto Arenas.

On the Isthmus of Panama, on account of its narrowness, there is but one direction to follow. No difficulties exist as far as Chiriqui, the territory being healthy and well cultivated. The rest of the Isthmus presents great obstacles, and one of the greatest for the carrying out of this enterprise is the well-known insalubrity of that region.

The general difficulties on all the lines of Central America are not insurmountable. They may necessitate the building of many works of art, like bridges, viaducts, steep grades, short curves, tunnels, etc. From surveys and lines in operation in this country, it can be said that this road is financially practicable in its entirety. All the railroads so far constructed in those regions have given satisfactory results in the end.

### South America.

Three routes could also be chosen in South America, viz.:

First. Between the Pacific ocean and the Andes.

Second. Following the so-called Andine region, utilizing the valleys and table-lands in that part of the Cordilleras.

Third. The route between the Andes and the Atlantic Ocean.

The first route would have its course in a region of about 100 miles in width, and does not seem advantageous owing to the fact that in Colombia and Ecuador that region is almost entirely a desert, and a very wild one. It is sufficiently populated in Peru

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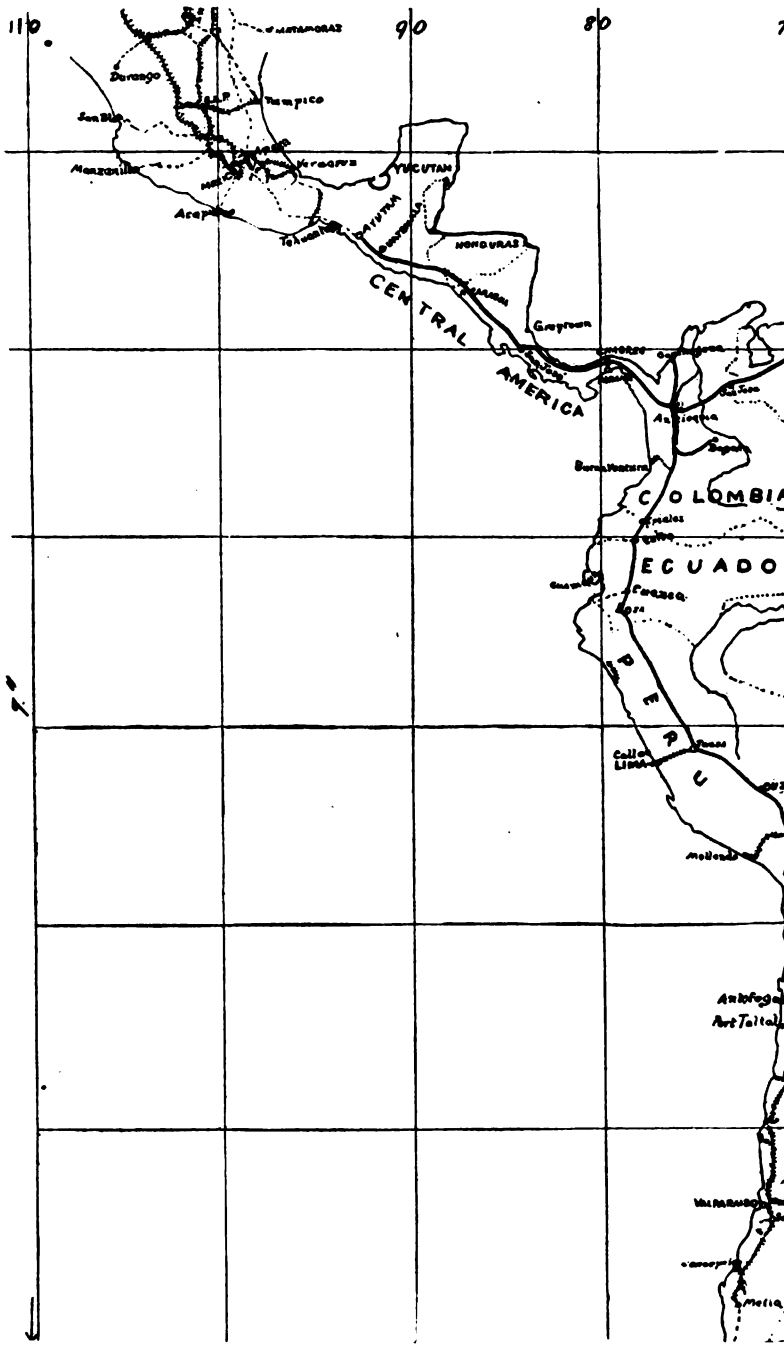


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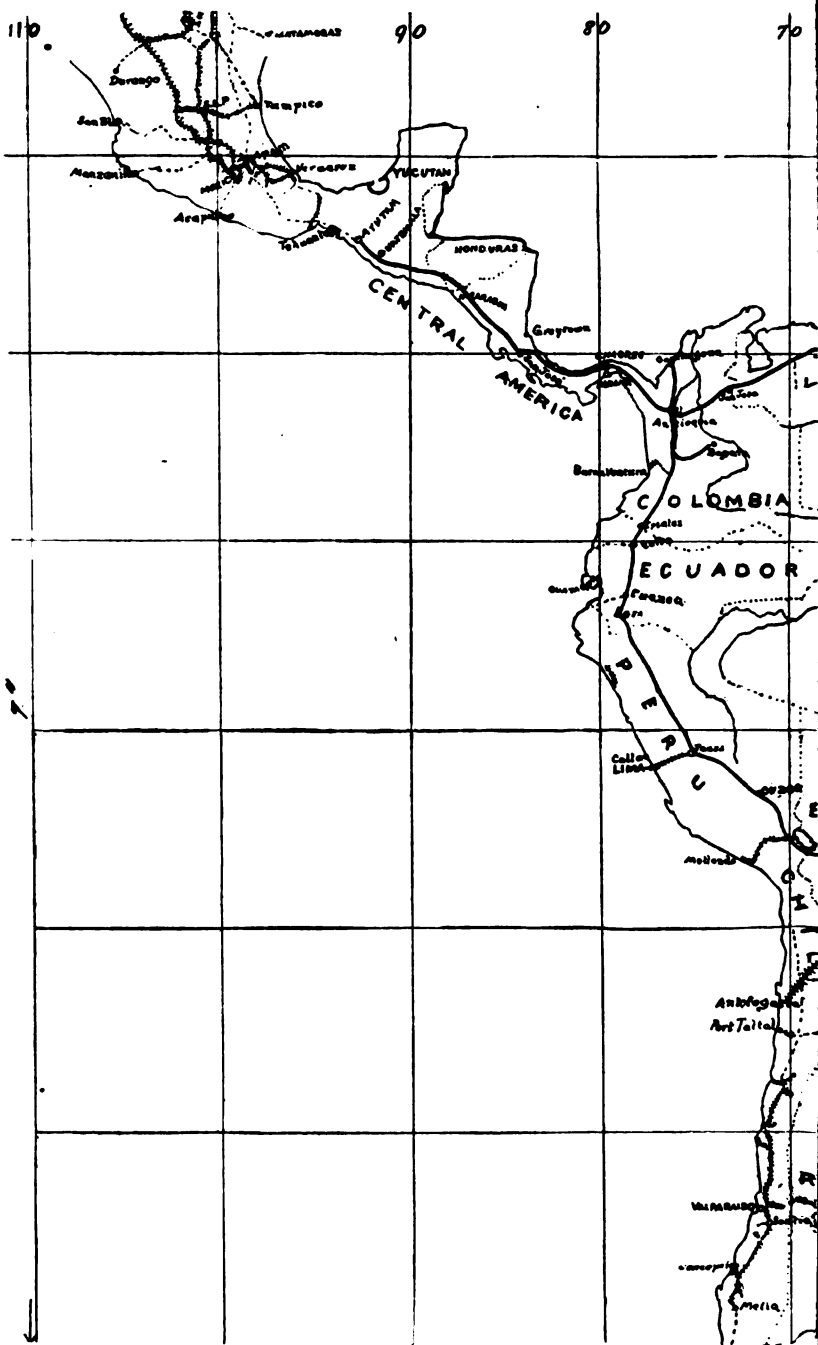


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and Chile, but the territory is arid, and only a few valuable mines may be found in it. By this line, moreover, several of the countries could not be directly connected, and it would necessitate the crossing, more than once, of the Andes, a very great drawback.

The eastern route, lying between the Andes and the Atlantic, would go through the most extensive and the wealthiest regions. Were it not for the necessity of building large and costly bridges over the many rivers, it would, without doubt, present the least difficulties for the construction of a railroad. Considering, however, the vast, unpopulated and unknown localities abounding in this region, the insalubrity of the country, the difficulty of building through extensive virgin forests, the absence, too, of the cities and centres of traffic, it is easy to perceive that this route is not the most desirable at present. It will, in the future, and with the development of the country, offer inducement for the development of a railroad line.

The eastern and western routes being excluded, there is only the third one, the Inter-Andine to be considered, and this has appeared to be, under all circumstances, the most advantageous.

As far as its physical aspect is concerned, it has great difficulties, the territory being mostly mountainous and broken. On the other hand, however, this route would unite the most populated and civilized places, and large sections of railroad already constructed or in construction could be utilized in its connections.

Leaving the Isthmus of Panama, this line would cross the Rio Atrato, in Colombia, go over the western Cordillera, and enter into the valley of the river Cauca near the city of Antioquia. This is one of the greatest difficulties to conquer. The line will continue as far as the head of the valley, passing Antioquia, a city of political and commercial importance, and by other populated centres, like Neira, Manizales, Cartajo, Buga, Palmira, Popayan; also, through the rich mining regions where gold, silver, and platinum are found.

On this portion of the route the crossing of the central range of mountains will be located so as to enable a branch line to connect the Magdalena valley and Bogota, a district of great commerce as well as of agricultural and mineral wealth, with the trunk line.

The route continues into the Patia valley, touching the city of

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Pasto. From Pasto it enters into Ecuador by Ipicales or Tulcan, and follows the Quito valley, the most populated region of this country, and connects, if possible, Quito, Cuenca, and Loja, or their vicinity.

From Ecuador, crossing the boundary where most practicable, the objective point should be to reach the vicinity of Cerro-de-Pazco. To attain this purpose the most desirable route, as far as mineral wealth and direction are concerned, is via Maranon valley, providing, however, that the section between the headwaters of the Maranon and Cerro-de-Pazco is practicable, even at a greater expenditure than by any other route.

Should this section be absolutely impracticable, it would be necessary to explore another route, farther east and via the Huallaca valley.

It is between Cerro-de-Pazco and Colombia that the greatest physical difficulties will be met. Beyond Cerro-de-Pazco the proposed route will have the advantage of utilizing a line now under construction from the head of the river Perene to its junction with the river Apurimac.

From this point the line should continue towards Sta. Ana, where it will meet another line, probably surveyed, to Cuzco, at which point it will join the railroad of Arequipa to Puno, which can be used as far as the Desaguadero river, on the Bolivian frontier, and continuing over the projected line to La Paz and Oruro, the terminus of the railroad now in operation between Huanchaca and Antofagasta on the Pacific coast, in Chile, uniting thus that republic with the trunk-line of the Inter-continental.

This route has, moreover, the advantage of utilizing a line projected and surveyed from Huanchaca to Jujuy, which will connect the Inter-continental with the system of the railroads of the Argentine republic.

Last, to study is the connection with Paraguay, Uraguay, and the United States of Brazil.

In regard to the two first-named republics, the commission recommends a line to start from Huanchaca and through the valley of the river Pilcomayo, to meet the lines included in the concession of Gen. Osbourne. This would be the most direct route, and the easiest line to build, and would advantageously use all the lines already constructed in these two countries.

As Brazil extends from 5° of latitude N. to the 33° latitude S.,

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and adjoins all the countries of South America intended to be connected by the Inter-continental Trunk-Line, many connecting links can be constructed between the principal line and Brazil, but, considering that the desired line must, with other favorable conditions, be the shortest in order to be remunerative, the Commission has chosen the indicated line from Huanahaca to Coxim, by way of Corumba. This line has the advantage of being the most direct one to the capital of Brazil.

It is also the shortest, considering that a road is already in operation between Rio Janeiro and Uberava, and a concession granted to prolong the same to Coxim. There is consequently only to survey and to construct a line between this latter point and the Inter-continental Trunk Line. Owing to its shortness it presents less physical difficulties; virgin forests and unexplored territories are not so extensive; it will also be noticed that there are not so many large rivers to cross.

Although the corresponding section of this line in Bolivia is not well known, it is, however, a fact that no great altitudes exist; moreover, that after reaching Corumba it will follow the valley of the river Taquary.

Commercially it is the line presenting the greatest elements of activity:

*First.* Because it connects the trunk line with the coffee regions of Brazil, and will carry this product to all the South American countries which do not produce it.

*Second.* It will, at Corumba, touch the river Paraguay, navigable up to that point, thus establishing water communication with Paraguay, the Argentine Republic and Uruguay, where it will gather traffic.

*Third.* It will establish a direct communication from the capital of Brazil to Chile, by the Huanchaca and Antofagasta Railroad, and also between the Atlantic and the Pacific, great sources of traffic.

The branch line to Venezuela runs not only through the northern slope of the Granadine Andes and its numerous and very extensive table-lands, but it opens a route by San Cristobal to the plains of the Republic, the great grazing lands of the country.

This branch crosses the States of Andes, Lara and Carabobo, and connects with the railroad under construction from Merida to

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San Carlos del Zulia, and with the Sanbana Demendoza line, soon to reach Trujillo.

These two tributary roads will establish communication with the State of Zulia, one of the richest and most important exporting regions of the country, owing to the navigable lake. The railroad from Barquisimeto to the harbor of Tucacas, the Valencia and Pto. Cabello and the Central Railroad, reaching the capital of the Republic, will all be connected by the projected branch.

Although the Venezuelan portion of the Inter-continental Railroad, as projected, runs through the mountainous region of that country, it is the one which would reach the largest populations and the most productive centres. It would, moreover, connect with railroads having great export traffic, as they all terminate at the seashore.

Consequently the projected Venezuelan branch would be the principal connecting link; it would collect the traffic of the country in the different States and at the most important harbors.

It is also likely that when this project is realized, the centre of the country will be in communication by rail with the eastern boundary of the Republic. The route of the projected connecting link between the Inter-continental Railroad and Venezuela, would remain unchanged should it even be decided to eventually run the trunk line through the valley of the Magdalena instead of the Cauca Valley.

The cost of the preliminary survey of this line was estimated at $350,000, and as the cash available from payments by the represented countries, at the rate of $1000 per million inhabitants per year, was not enough to guarantee the sending out of all the expeditions contemplated, with the certainty of not being compelled to recall them before their allotted task was done, it was resolved to send out only three expeditions to cover the proposed line from Mexico to Cerro-de-Pasco, Peru, including in this all the critical points of the road.

Whilst the route was being studied, the organization of the three parties to go on the field had been perfected, and the work was divided as follows: Party No. 1 to study the Central American section, beginning at Ayutla, Guatemala, and working down to the Isthmus of Panama. This corps is composed in its main part of officers of the United States Army, under the command of Lieutenant M. M. Macomb, detached from West Point for the

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purpose. The party being fully equipped with provisions, duplicate instruments for stadia work, transits, odometres, etc., sailed for their destination on the 20th of April last.

Parties Nos. 2 and 3, under the leadership of Mr. Wm. F. Shunk, the well known railroad engineer, assisted by Mr. J. Imbrie Miller, with a complete equipment for each party, sailed on the 10th of the same month for Quito, Ecuador, and there, after a careful study of the ground and organizing for active work in conjunction with the assistants furnished by the Government of Ecuador and later on by Colombia and Peru, as they enter the respective territories, they separated, party No. 2 under Mr. Shunk working northward into Colombia, surveying the line included between the starting point and the crossing of the Atrato river at the Isthmus, the branches to Bogotá, Cartagena and to Venezuela. Party No. 2 under Mr. Miller will travel southward to Cerro de Pasco, Peru, carefully studying the best route to the last named place. Each party as well as No. 1 is accompanied by a surgeon of the United States Navy.

As new yearly appropriations are made by the respective countries new expeditions will be sent out to survey the remaining parts of the line.

In making these surveys the engineer in charge will try, as far as practicable, to follow the general route as indicated. It is, however, in his discretion to alter it whenever his observations and the information gathered on the ground will make him decide in favor of a more practicable route, both technically and economically.

These surveys must be sufficiently studied, calculated and figured to present as nearly as possible the topography of the region. They shall also, as far as practicable, determine the geographical positions of the most important points through which the line will have to run. They will also determine the general direction of the rivers, the valleys and mountains crossed by the line; also the slopes and the maximum flow of water, and all other information commonly obtained by a preliminary survey.

In crossing mountains, the maximum curves and minimum grades at the points that the line must reach shall be determined approximately.

The surveying parties shall procure a description of the different geological formations of the ground, and statistical data which might be valuable for the final location of the line, such as the exten-

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sion of the cultivated, uncultivated and grazing lands, the extension of the private and national properties, all existing and available materials for construction, the mineral wealth and facilities of development, the population, condition of climate and salubrity, etc.

The field maps are to be made on a scale of 1 on 24.000, and profiles on same horizontal scale, and 1 on 2400 vertical.

The plans are to be accompanied by a descriptive memoir, illustrated by sketches and photographs, and relating how the observations and information were obtained and the difficulties surmounted; at the end of each day's work an approximate estimate of the cost of the section of line surveyed will be made.

The reports of the expeditions are awaited with great interest, for the importance of the projected railroad cannot be over-estimated when it is considered that it will open up a range of country larger than the United States, and fully as rich, and develop mines whose wealth is unrivalled; but that to-day, owing to the impossibility of transporting the heavy machinery and the ore to and from the mines are practically worthless.

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## THE SHADOW OF A CIRCLE.

### Investigation of its Geometric Properties and Relations.

By A. D. F. HAMLIN.

In architectural drawings, especially on geometrical elevations, the correct casting of the shades and shadows is an important factor in the effective expression of the design. To the architect, therefore, sciography is one of the most important branches of descriptive geometry; although, as its applications in his practice are nearly all in the nature of special problems, it is rarely studied in its abstract and mathematical relations. That these, however, may sometimes be both instructive and curious, appears from the careful investigation of the properties, geometrical and numerical, or quantitative, of some even of the simpler and commoner shades and shadows, as of the circle, sphere, square, cube, etc.

Let us consider the case of the horizontal or vertical circle, par-

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allel to one and perpendicular to the other plane of projection, or perpendicular to both. These cases comprise nine-tenths of all the circles occurring in architectural designs. The shadow of such a circle, falling upon a plane parallel to it, will obviously be a circle, whatever the angular direction of the light. When cast upon a plane at right ahgles to that of the circle (as the shadow of a horizontal circle on the vertical plane of projection, or of a circle perpendicular to both planes of projection, upon either of them), the shadow is an ellipse whose proportions vary with the angular direction of the light. In ordinary practice this is assumed to be at 35° 16′ (nearly) with both planes of projection, that is, in the direction of the diagonal of a cube; its projection on either plane is at 45° to the ground line. The convenience of this assumption is familiar to every draughtsman, and the artistic effect of the shadow cast at this angle is as undeniable as its value in correctly expressing or suggesting the third dimension, and thus compensating for the absence of perspective.

The common method of drawing the elliptical shadow of the circle perpendicular to the plane of projection, is to cast the shadow of the circumscribed square, which (with the light projected at 45°) is a parallelogram having two sides equal and parallel to the rectilinear projection of the circle, and two at 45° to it and equal to the diagonal of the square. The ellipse is more or less accurately inscribed in this parallelogram, tangent to the middle of each of its sides. Greater accuracy is secured by using the shadow of the circumscribed octagon instead of that of the square.

But this furnishes no accurate process for describing the ellipse, of which it gives neither the foci nor the axes, nor the inclination of the latter. To ascertain these data we invoke the aid of the differential calculus, as will be presently shown.

It is first necessary to find a general formula for the length of the shadow cast on one plane of projection by a line parallel to the other plane. Then, we can ascertain the relation between the length and inclination of any diameter of the circle and its shadow. And, since the major axis of the ellipse is the longest, and the minor axis the shortest, shadow cast by any diameter of the circle, the principle of maxima and minima of differentials will enable us to identify the diameters whose shadows are the axes of the ellipse of shadow, and to determine the length and inclination of these axes. Figure 1 shows the horizontal circle *a b c d* in both hori-

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zontal and vertical projection with the elliptical shadow $a'_1 c'_1 b'_1 d''_1$ cast on the vertical plane (which we will call VP). A and B are the two diameters whose shadows $a'_1 b'_1$ and $c'_1 d''_1$ are the axes of the ellipse. To determine the inclination and relative lengths of diameters and axes is our problem.

Let $ab$, $a'b'$ in Fig. 2 be the projections of a horizontal line, the di-

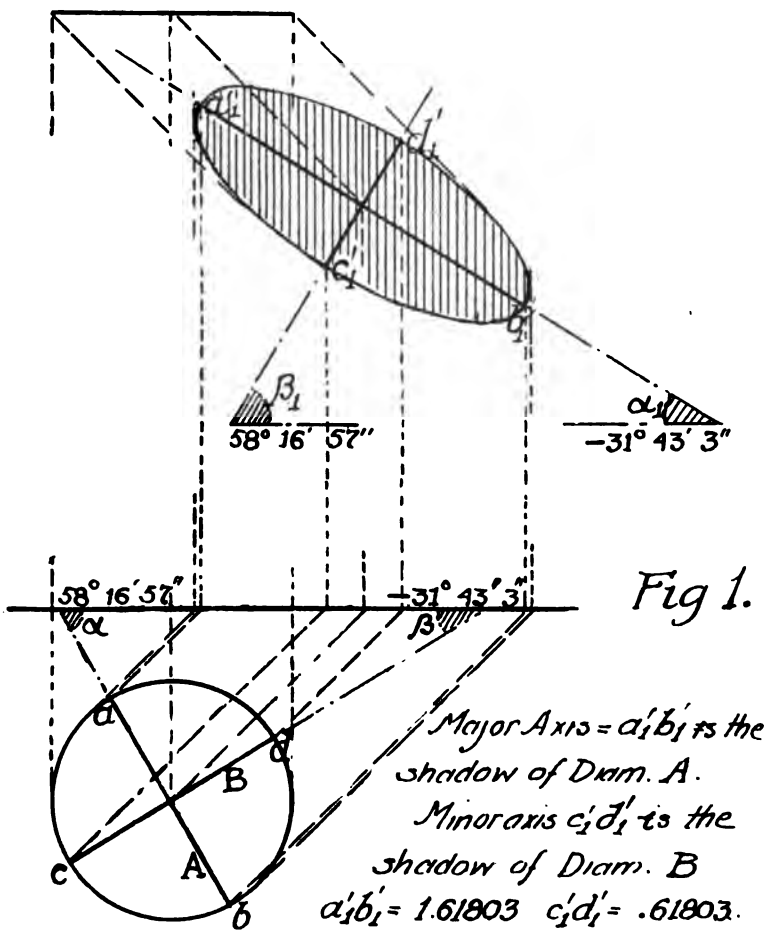
58° 16' 57"
−31° 43' 3"
58° 16' 57"
−31° 43' 3"
Major Axis = $a'_1 b'_1$ is the shadow of Diam. A.
Minor axis $c'_1 d'_1$ is the shadow of Diam. B
$a'_1 b'_1$ = 1.61803 $c'_1 d'_1$ = .61803.

Fig 1.

ameter of the given circle, for example; its shadow on VP will be $a'_1 b'_1$. Draw $a'_1 c$ and $ae$; the angle $eab$ (or the inclination of $ab$, $a'b'$ to VP) we will call $\alpha$, and its shadow, $ca'_1 b'_1$, we will designate as $\alpha'_1$. Call $ab$, $a'b'$, A, and the length of $a'_1 b'_1$, $l$; then, from the demonstration appended to Fig. 2, it appears that $l^2 = (\cos. \alpha + \sin. \alpha)^2$

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$+ \sin.^2 a$, whence developing and remembering that $\sin.^2 a + \cos.^2 a = 1$, we have

$$l^2 = 1 + 2 \cos. a \sin. a + \sin.^2 a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Differentiating and dividing by 2, we have

$$l \frac{dl}{da} = \cos.^2 a - \sin.^2 a + \sin. a \cos. a \quad . \quad . \quad . \quad . \quad . \quad (2)$$

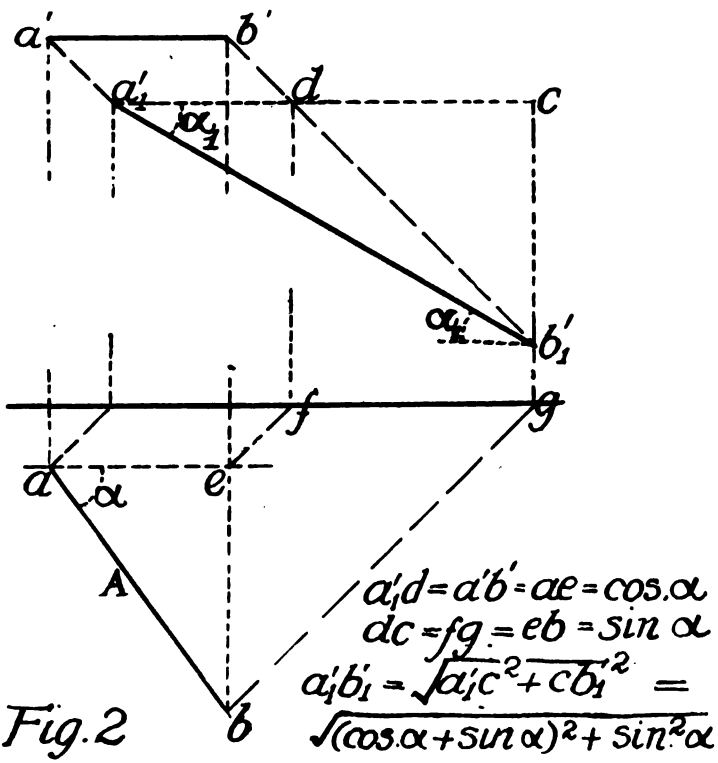


Fig. 2

But for maximum and minimum values of $l$, $\frac{dl}{da} = 0$, and the above equation, by transposing and dividing throughout by $\cos.^2 a$ becomes $\frac{\sin.^2 a}{\cos.^2 a} - \frac{\sin. a}{\cos. a} = 1$, whence,

$$\tan.^2 a - \tan. a = 1. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$



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Completing the square and extracting its roots we have tan. $\alpha - \frac{1}{2} = \pm\sqrt{\frac{5}{4}}$ or in other words,

$$\text{tan. } \alpha = \frac{1 \pm \sqrt{5}}{2} \quad \ldots\ldots\ldots \quad (4)$$

The two values of the root, corresponding to the maximum and minimum values of $l$, are found by the table of logarithms to be 1.61803 and —.61803, which are the tangents of the angles $\alpha$ made with the VP by the diameters of the circle which cast repectively the longest and shortest shadows of all. These angles are found to be 58° 16′ 57″ and 31° 43′ 3′ very nearly. We will distinguish the angle of inclination of $B$ (in Fig. 2) by the letter $\beta$, whence

$$\alpha = 58° 16' 57''; \ \beta = -31° 43' 3'' \quad \ldots\ldots \quad (5)$$

Now to find the length of $l$, we may substitute in (1) the easily ascertained values of sin. $\alpha$ and cos. $\alpha$, sin. $\beta$ and cos. $\beta$ ($\alpha$ and $\beta$ being complementary, so that sin. $\alpha$ = cos. $\beta$, and cos. $\alpha$ = sin. $\beta$), giving us as the value of $l$ with the angle $\alpha$ = 58° 16′ 57″,

$$l = \sqrt{1 + .894426 + .723605} = 1.61803 \quad \ldots \quad (6)$$

which is the length of the major axis of the ellipse in terms of the diameter of the circle; and for the angle $\beta$ = — 31° 43′ 31″,

$$l = \sqrt{1 - .894426 + .266494} = .61803 \quad \ldots \quad (7)$$

a very curious result, certainly. That is to say, *the length of either axis of the ellipse of shadow is equal to the tangent of the angle made with VP by the diameter whose shadow it is, the diameter being taken as unity.* It has already appeared, from the mere inspection of the ascertained values of $\alpha$ and $\beta$, that they are complementary angles; that is to say, *the axes of the ellipse are shadows of diameters of the circle at right angles to each other*, and these are the only conjugate diameters of the circle whose shadows are perpendicular to each other.

To ascertain the inclination of the axes of the ellipse to the horizon is next in order. Let $\alpha_1$ be that of the major axis and $\beta_2$

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that of the minor axis, which we will call $l'$ (Fig. 1), their values are computed by the following proportions, which appear upon inspection of Fig. 2, in which if the length of $ab = 1$ be laid off on $a'_1b'_1$ to a point $b^2$, and from $b^2$ a perpendicular, $b^2e^2$ be erected to $a'_1c$; then $b^2e^2 = \text{sin. } \alpha_1$, and (since $cb'_1 = dc = eb = \text{sin. } \alpha$) we have sin $\alpha$ : sin $\alpha_1$ : : $l$ : 1, whence

$$\text{sin. } \alpha_1 = \frac{\text{sin. } \alpha}{l} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

and similarly it may be proved that

$$\text{sin. } \beta_1 = \frac{\text{sin. } \beta}{l'} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The values of sin. $\alpha$ and sin. $\beta$ have already been ascertained from the tables in finding the value of $l$ in (6); they are .85065 and .52573 respectively, so that

$$\text{sin. } \alpha_1 = \frac{.85975}{1.61803} = .52573 = \text{sin. } 31^\circ\, 43'\, 3'' \quad . \quad . \quad (10)$$

and

$$\text{sin } \beta_1 = \frac{-.52573}{.61803} = .85065 = \text{sin} - 58^\circ\, 16'\, 57'' \quad . \quad (11)$$

which is as surprising as the other results obtained. That is, *the inclination of either axis of the ellipse is the complement of the angle made with VP by the diameter whose shadow it is, and therefore equal to that made by the other diameter.* The inversion of these signs in Fig. 1 is due to the fact of the angles being measured *below* the axis, while the proportions derived from Fig. 2 were based on angles measured in the reverse direction (as $\alpha_1$ in Fig. 2 lies below the horizontal line, while in Fig. 1 it is above it).*

Since $l = 1.61803 = \text{tan. } \alpha$ and $l' = .61803 = \text{tan. } \beta$, we might have deduced the values of $\alpha_1$ and $\beta_1$ without recourse to tables and computations; for, from (8), $sin.\ \alpha_1 = \frac{sin.\ \alpha}{l} = \frac{sin.\ \alpha}{tan.\ \alpha} = \text{cos. } \alpha$; that

* In the above results allowance has been made for minute errors arising in the use of the logarithmic tables, and affecting only the fourth and fifth decimal places; they in no wise affect the substantial accuracy of the results or the surprising and interesting relations they reveal.

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is, $\alpha_1$ and $\alpha$ are complementary, and similarly, *sin* $\beta_1 = \frac{\sin \beta}{-\tan \beta} =$ $-\cos \beta$, that is, $\beta_1$ is negative and the complement of $\beta$, which accords with the other result.

Besides these curious relations, it appears also that the *inclination* $\alpha_1$ *of the major axis is one-half that of the* diagonal *of the shadow on VP of the vertical square perpendicular to VP*, this diagonal being inclined at 63° 26′ 6″ to the horizon. This relation suggests a method for laying off the axes of the ellipse at the correct angle and of the correct length by a comparatively simple geometrical process, but it hardly falls within the scope and limits of the present article. It may be found described in the *American Architect* for February 14, 1891.

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## THE FILLING OF MINERAL VEINS.

By J. F. KEMP.

*The Source of the Metals.*—The metallic contents of the minerals which constitute ores, must logically be referred to a source either in the igneous rocks or in the ocean. If the nebular hypothesis expresses the truth, and it is the best formulation that we have, all rocks, igneous, sedimentary, and metamorphic, must be traced back to the original nebula. This, in cooling, afforded a fused magma, which chilled and assumed a structure analogous to the igneous rocks with which we are familiar. Igneous rocks have thus, necessarily, furnished by their erosion and degradation the materials of the sedimentary rocks, and igneous and sedimentary have alike afforded the substances whose alterations have produced the metamorphic rocks. It may also be true that eruptive rocks, especially when basic, have been formed by the oxidation and combination with silica, of inner metallic portions of the earth, for such is one of our most reasonable explanations of volcanic phenomena, suggested alike by the composition of basalts, by the high average specific gravity of the globe, and by the analogy of meteorites.

As opposed to this conception, there are those who would derive the metallic elements of ores from the ocean, in which they have been dissolved from its earliest condensation. Thus, it is

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said, that substantially all the metals are in solution in the sea-water. From the sea they are separated by organic life, it may be through sulphurous precipitation attendant on the decay of dead plants or animals. The accumulation of the remains of organisms brings the metals into the sedimentary strata. Once thus entombed, circulations may concentrate them in cavities. When present in igneous rocks, the latter are regarded as derived from fused sediments.* If the metallic contents of sedimentary rocks do not come from the ocean in this way, the igneous rocks as outlined above are the only possible source. No special mention is here made of the metamorphic rocks, because, in their original state, they are referable to one or the other of the two remaining classes. But it is not justifiable, in the absence of special proof, to consider them altered sediments, any more than altered igneous rocks, and it is doubtless true, that the too generally and easily admitted sedimentary origin for our gneisses and schists, has materially hindered the advance of our knowledge of them in the last forty years.

Microscopic study of the igneous rocks has shown that, with few exceptions, the rock-making minerals separate from a fused magma on cooling and crystallizing, in a quite definite order.† Thus, the first to form are certain oxides, magnetite, specular hematite, ilmenite, rarely chromite and picotite, a few silicates, unimportant in this connection (zircon, titanite), and the sulphides pyrite or pyrrhotite. Next after these metallic oxides, etc., the heavy dark-colored basic silicates, olivine, biotite, augite, and hornblende, are formed. All these minerals are characterized by high percentages of iron, magnesium, calcium and aluminum. They are very generally provided with inclusions of the first set. Following the bisilicates in the order of crystallization, come the feldspars, and after these, when some residual silica remains uncombined, it separates as quartz.

If we regard the igneous rocks as the source, the metallic elements are thus to be found in the first and second series of crystallizations, while the elements of the gangue minerals are derived from the last three. It is a doubtful point, whether the less common

* R. Pumpelly, article on "Ore-Deposits," Johnson's *Encyclopædia*, vol. vi., p. 22. J. S. Newberry, "Deposition of Ores," the QUARTERLY, v., 337. J. Leconte, "Genesis of Metalliferous Veins," *Amer. Jour. Sci.*, iii., xxvi., foot of page 13.

† H. Rosenbusch, "Ueber das Wisen der Körnigen und Porphyrischen Structur bei Massengesteinen," *Neues Jahrbuch*, 1882, ii., 1.

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metals, such as copper, silver, and nickel, enter into the composition of the dark silicates as bases, replacing the iron, alumina, lime, etc., or whether they are present in them purely as inclusions of the first series. F. Sandberger* argues in support of the first view, but his critics, notably A. W. Stelzner, cast doubt upon his conclusions on the ground that his chemical methods were indecisive. The case is briefly this. Sandberger, as an advocate of views which will be subsequently outlined, separated the dark silicates of a great many rocks. By operating on quantities of 30 grams he proved the presence in them of lead, copper, tin, antimony, arsenic, nickel, cobalt, bismuth, and silver, and considers these metals to act as bases. The weak point of the demonstration consists in dissolving out any possible inclusions from the powdered silicate. There seems to be no available solvent which will take the inclusions and be without effect on the silicates. This is the point attacked by the critics,† and apparently with reason. It is, however, important to have shown the presence of these metals, even though their exact relations be thus doubtful. The existence of silver in quartz-porphyry has been demonstrated in this country by J. S. Curtis,‡ at Eureka, Nev.; both the precious metals have been shown by G. F. Becker§ to be in the diabase near the Comstock lode; and, by the same investigator,‖ antimony, arsenic, lead, copper, gold, and silver, were proved to be contained in the granite near Steamboat Springs, Nev. S. F. Emmons¶ has also shown that the porphyries at Leadville contain appreciable, though small amounts of silver. Of forty-two specimens tested, thirty-two afforded it; of seventeen tested for lead, fourteen yielded results. Undoubtedly, the multiplication of tests will show similar metallic contents in other regions. Thus the augite of the Triassic diabase will probably yield copper, for this metal is abundant in connection with the outflows.

* The principal paper of Professor Sandberger is his "Untersuchungen über Erzgänge," 1882, abstracted in the *Eng. and Min. Jour.*, March 15, 22, 29, 1884: but a long series of others might be cited in which the investigations, notably at Pribram, Bohemia, are interpreted as indicated above.

† A. W Stelzner, *B. & H Zeit*, xxxix., No. 3. *Zeitsch, d. d. g., Gesell.* xxxi., 644. "Die Lateralsecretions-Theorie, etc." Reprint, Freiberg, 1889.

‡ Monograph vii., U. S. Geol. Survey.

§ Monograph iii., U. S. Geol. Survey.

‖ Monograph xiii., U. S. Geol. Survey

¶ Monograph xii., U. S. Geol. Survey.

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*The Methods of Filling.*—Methods of filling were summed up a very long time ago by v. Herder and v. Cotta* as follows: 1. Contemporaneous formation. 2. Lateral secretion. 3. Descension. 4. Ascension by infiltration or by sublimation with steam, or by sublimation as gas, or by igneous injection. To these should be added the more recent theory of 5. Replacement, which, however, is rather a method of precipitation than of derivation. No one longer believes in contemporaneous formation, and descension has an extremely limited, if indeed any application. Ascension by sublimation as gas or with steam, or by igneous injection, finds few, if any supporters. The discussion is practically reduced to lateral secretion and ascension by infiltration.

*Lateral Secretion.*—By lateral secretion is understood the derivation of the contents of a vein from the wall rock. The wall rock may vary in character along the strike and in depth. Three interpretations may be made, two of which approach a common middle ground with ascension by infiltration. It may first be supposed that the vein has been filled by the waters near the surface, which are known to be soaking through all bodies of rock, even where no marked water-way exists, and which ooze from the walls of any opening which may be afforded. Being at or within comparatively short distances of the surface, the waters are not especially heated. As they emerge to the oxidizing and evaporating influence of the air in the cavity, their burden of mineral is deposited as layers on the walls. The second interpretation supposes the walls to be placed during the time of filling at considerable depths below the surface, so that the percolating waters are brought within the regions of elevated temperature and pressure. Essentially the same action takes place as in the first case. The third interpretation increases the extent of rock leached. Thus if a mass of granite encloses a vein and extends to vast depths, we may suppose the waters to come from considerable distances, and to derive their dissolved minerals from a great amount of rock of the same kind as the walls. Portions of this may even be in the regions of heat and high temperature, while the place of precipitation is nearer the surface. These latter two interpretations have much in common with the theory of ascension by infiltration, and on this common middle ground

* *Erzlagerstätten*, 2d edition, 1859. Vol. i., p. 172.

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lateral secretionists and infiltration ascensionists may be in harmony.

*Ascension by Infiltration.*—The theory of infiltration by ascension in solution from below considers that ore-bearing solutions have come from the heated zones of the earth, and that they rise through cavities, and at diminished temperatures and pressures deposit their burdens. No restriction is placed on the source from which the mineral matter has been derived. Indeed, beyond, that it is "below," and yet within the limits reached by waters, all of which have descended from the surface, and that the metals have been gathered up from a disseminated condition in rocks igneous, sedimentary and metamorphic; no more definite statement is possible. It is of necessity largely speculative, because the materials for its verification are beyond actual investigation.

In favor of lateral secretion the following arguments may be advanced: 1. According to Sandberger, actual experience with the conduits, either natural or artificial, of mineral springs, shows that a deposit seldom if ever gathers in a moving current. It is only when solutions come to rest on the surface and are exposed to oxidation and evaporation that precipitation ensues. Deposits in veins have therefore formed in standing waters whose slight overflow or evaporation would be best compensated by the equally slight and gradual inflow from the walls. If, in hot springs, there were a strong and continuous flow from below and discharge from above, the mineral matter would reach the surface. (Sandberger, *Untersuchungen uber Erzgange*, Heft 1). Hence the deposit would be more likely to gather in the slow infiltration from the wall rock, which would stand in cavities like a well. We have, however, some striking instances of deposits in artificial conduits. Professor H. S. Munroe has called the writer's attention to a case met by him the past summer. The 14-inch column pipe of a pump at the Indian Ridge Colliery, Shenandoah, Penna., which was raising ferruginous waters, became reduced in diameter to 5 inches within two years by the deposit of limonite. The same amount of water was forced through the 5-inch conduit as the 14. By figuring out the stroke and cylinder contents, it is found that in the clear pipe the water moved 162 feet per minute, and in the contracted, 1268 feet per minute. And yet the deposit gathered. The condition necessitated the continuous action of the pump and it was not idle over two hours in each two months of that period.

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The boiler-feed pipes of steamers plying on the great lakes also become coated with salts of lime. Years ago a disastrous boiler explosion occurred from the virtual stoppage of the feed by this precipitation.

2. If a vein were opened up in mining, which ran through two different kinds of rock, and if in the one rock one kind of ore and gangue minerals were found, and in the other a different set, the wall rock would clearly have some influence. Thus in a mine at Schapbach, in the Black Forest, investigated by Sandberger, a vein ran through granite and gneiss. The mica of the granite contained arsenic, copper, cobalt, bismuth and silver, but no lead. The principal ore in this portion was gray copper. The mica of the gneiss contained lead, copper, cobalt and bismuth, and the vein held galena, chalcopyrite and a rare mineral, schapbachite, containing bismuth and silver, but probably a mixture of several sulphides. No two ores were common to both parts of the vein. Another well established foreign illustration is at Klausen, in the Austrian Tyrol: lead, silver and zinc occurred in the veins where they cut diorite and slates, but copper where mica schist and felsite formed the walls. In America there are a number of similar cases. At the famous Silver Islet Mine,* on Lake Superior, the vein runs through unaltered flags and shales, and then crosses and faults a large diorite dike. When the diorite forms the walls, the vein carries native silver and sulphides of lead, nickel, zinc, etc., but where the flags form the walls, the vein carries only barren calcite. Along the edges of the estuary Triassic sandstones of the Atlantic border, where they adjoin Archæan gneiss, a number of veins are found carrying lead minerals, while in the sandstones near the well known diabase sheets and dikes, are others carrying copper ores. It was early remarked by J. D. Whitney that the lead was usually associated with the gneiss, the copper with the diabase.

From instances like these it is inferred that the ores were derived each from its own walls, and by just such a leaching action by cold surface waters as is outlined above. As opposed to this,

* W. M. Courtis, "On Silver Islet," *Eng. and Min. Jour.*, Dec. 21, 1878. *Inst. Min. Eng.*, v., 474.

F. A. Lowe, "The Silver Islet Mine, etc.," *Eng. and Min. Jour.*, Dec, 16, 1882, p. 321.

T. MacFarlane, "Silver Islet," *Inst. Min. Eng.*, viii., 226. *Canadian Naturalist*, iv., 37.

McDermott, *Eng. and Min. Jour.*, Jan., 1877.

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it has usually been claimed that each particular wall exerted a peculiar selective and precipitating action on the metals found adjacent to it, and none on the others; so that if a solution arose carrying both sets, each came down in its particular surroundings, while the others escaped. Mr. W. P. Jenney has called the writer's attention to such a case. The Head Centre mine, in the Tombstone District, Arizona, is on a vein which pierces slates, and in one place forty feet of limestone. In the slates it carried high-grade silver ores, with no lead, but in the limestone lead-silver ores. A rock like limestone might well exercise a precipitating action, which, however, we cannot attribute to rocks composed of the more inert silicates. Again, it has been said that the solutions coming from below have varied in different portions of the vein or at different periods. An earlier opening would thus be filled with one ore, a later with another. This is hypothetical, but has been advanced for Klausen by Posepny (*Archiv. f. Praktische Geologie*, p. 482). A further general objection to the first interpretation of lateral secretion is the weak dissolving power of cold surface waters, and this is a very serious one.

As opposed to the second interpretation, it may be advanced that precipitation in a cavity at a great depth would be retarded by the heat and pressure to just that extent to which solution in the neighboring walls would be aided. The temperature and pressure being practically the same, the tendency to remain in solution would be great until the minerals had reached upper regions and filled the cavity by ascension. Under such circumstances ores would only be deposited below by some such action as replacement. To the third interpretation no theoretical objections can be made.

*Infiltration by Ascension.*—On the side of infiltration by ascension, if two veins or sets of veins were found in the same wall-rock, but with different kinds of ores and minerals, the conclusion would be irrefutable that the respective solutions which formed them had come from two different sources below. Thus, at Butte, Montana, there is a great development of a dark basic granite. It contains two series of veins, of which the southern produces copper sulphides in a siliceous gangue, the northern, sulphides of silver, lead, zinc and iron, also in a siliceous gangue, but abundantly associated with manganese minerals, especially rhodonite. No manganese occurs in the copper belt, nor is any copper found in the

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silver belt. Such results could only originate in different deep-seated sources. Again, at Steamboat Springs, Nevada, and Sulphur Bank, California, the hot springs are still in action and are bringing their burdens of ore and gangue to the surface. The former has afforded a long series of metals, the latter chiefly cinnabar. G. F. Becker* has shown that the cinnabar probably comes up in solution with alkaline sulphides.

*Replacement.*—The chemistry of the replacement process is none too well understood, but it presents less difficulties when applied to a soluble rock, like limestone or dolomite, than when the rocks composed of silicates and quartz have given way to ores. Acid solutions would readily yield to calcium carbonate, but if the metals are present as sulphates, some reducing agent is necessary, such as organic matter, in order to change the metallic sulphate to sulphide.† Or else, if the metallic sulphides came up in solution with alkaline sulphides, some third agent is needed to remove the calcium carbonate, *pari passu*, just before the metallic sulphide is precipitated. It must be confessed that for enormous bodies of ore, like those of Leadville, the small amount of organic matter present seems hardly equal to the task assigned it, and the delicate balance of the latter case—causing deposit to tread so closely on the heels of rock removal, in order to avoid assuming an extended cavity—makes it appear that the entire chemistry of the process is perhaps hardly yet understood.

Where silicate rocks are replaced, leaving a siliceous gangue, the process may have been somewhat as suggested by R. C. Hills for the mines of Summit Peak, Rio Grande Co., Colo. (See *Proc. Colo. Sci. Soc.*, vol. i., p. 20). Alkaline solutions remove silica and have slight action on silicates, but solutions acid with sulphuric acid attack silicates, such as feldspar and biotite, remove the alumina or change it to kaolin, and cause the separation of free silica. In the alteration product abundant opportunity would be afforded for the precipitation of sulphides, which would replace—in part, at least—the rock. Along a crack or line of drainage definite walls would thus easily fade out. Such phenomena

* G. F. Becker, "Natural Solutions of Cinnabar, Gold and Associated Sulphides," *Amer. Jour. Sci.*, iii., xxxiii., 199; 8th Ann. Rep. Dir. U. S. G. S., p. 965, Monograph xiii., U. S. Geol. Surv.

† Compare S. F. Emmons' On the Replacement of Leadville Limestones and Dolomites by Sulphides, monograph xii., U. S. Geol. Sur., p. 563.

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are afforded by innumerable ore-deposits (see R. W. Raymond, Discussion of S. F. Emmons' "Notes on the Geology of Butte, Mont.," *Trans. Inst. Min. Eng.*, July, 1877), and often come under the notice of every one familiar with mining. Yet we cannot but hope that in the future our knowledge of the chemical reaction involved will be increased.

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## MINE ROPES.*

THE report on mine ropes in Belgium, England, and Germany, made to the French government by Aquillon, may be thus summarized:

With regard to the material for pit-ropes, whether hemp, or iron, or steel wire, and their shape, whether round or flat, the advantages attributed to hemp ropes, of giving warning before they break, is shared equally by wire ropes when properly looked after, and the latter can be employed with as much safety as hemp ropes, when proper care is bestowed upon everything affecting their working. In wet pits, particularly where the water is at all corrosive, or where it is wound up in buckets instead of being pumped, aloes ropes are preferable. But in up-cast shafts, however slightly warm be the air-current, wire ropes should be used in spite of the disadvantage of their hemp core. In the absence of any such special reasons the choice of material is more a question of economy and convenience than of safety. Where it is determined that the rope shall be flat instead of round, the power of the winding engine in deep pits can be better balanced with a hemp rope, because a flat wire rope is too thin to alter the leverage quickly enough in coiling or uncoiling on the rope roll, and would involve some kind of counterbalance, which would be a matter of difficulty. This is the practical reason why several deep pits in France have recently changed from flat wire ropes to flat aloes ropes. With wire, too, there is much more difficulty in making a good flat rope than a good round one; and round ropes winding on conical or spiral drums afford a convenient means of balancing the engine power. As to the

* From Report of the Secretary for Mines for Victoria during the year 1890.

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choice between steel and iron for wire ropes, German and English practice goes to show that steel ropes, well made and of a suitable quality of steel, are capable of working better in all respects, and appear even to be safer. The exclusive use of steel wire ropes in Germany and England, and of hemp or aloes ropes in Belgium, for all depths of pit, is attributed to the degree of excellence which has been arrived at in the two former steel-producing countries in the manufacture of steel wire of sufficiently homogeneous quality and otherwise suitable for ropes; whereas in Belgium the manufacture of aloes or hemp ropes has always been a special industry of Flanders, where it has attained a rare degree of perfection. The whole of the winding-gear should always be carefully adapted to the particular material of which the ropes are made. In France the mistake has generally been committed of ordering a rope without giving the maker any idea of the conditions under which it is to work, the very make being often specified for him in detail. Elsewhere the more sensible practice is to consult with the maker throughout, furnishing him with complete information as to the whole of the requirements to be fulfilled.

In addition to being tested, all ropes should be guaranteed by the makers. In Belgium the guarantee for aloes ropes is generally that they shall last 1½–2½ years, or else for a given output; and 1-12th or 1-24th of their value is deducted for every month short of their stipulated duration. At the Royal Collieries at Saarbrücken, the ropes, of English crucible cast-steel wire are guaranteed for six weeks, during which the maker is held liable to replace them if found defective. Testing should apply for hemp and aloes ropes, both to the raw material itself and to the spun-yarn, as well as to sample lengths of the finished ropes. The twist of the rope and the stitching of a flat rope should be very uniform; and the rope should not contain more than 20 per cent. of tar.

Iron wire for ropes should be strong, hard, pliable, and not galvanized, and should be selected from standard makes. Steel wire should be made from crucible cast-steel, of very homogeneous and comparatively hard quality, and suitably annealed; it should have a tensile strength of 70–76 tons per square inch, and should stretch 3–5 per cent. and be pliable. It should be tested for tensile strength, stretching, bending, and torsion; and all the wires in the same rope should be as closely alike as possible. Sample lengths of the rope itself should also be tested. The lay of the wires and strands

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should be regular; in flat ropes the stitching should be regular, and should be done with annealed wire. Torsion is considered an excellent test for homogeneous quality in wire; steel wires of 0.059 inch and 0.118 inch diameter should stand twisting through 40 and 20 revolutions respectively in an unloaded length of 6 in.; and the surface markings produced by the twisting should follow regular lines.

The size of the wires and length of their lay or pitch in the rope should vary in accordance with the diameter of the drums and pulleys round which the rope will have to work, and particularly with the distance between the drum and the pit-head pulley, and with the angle which the inclined span winding on the drum makes with the vertical portion hanging down the pit. These are essential points for determining the stiffness requisite to prevent the rope from flapping as it runs.

Experience proves that the very material itself of every rope does certainly undergo deterioration in working, thereby diminishing the rope's strength till it becomes no longer safe. This deterioration of material is something more than mere wear by friction or rusting; in aloes ropes the fibres lose their strength, and in wire ropes, even where testing fails to show any loss of tensile strength per square inch of section, there is a clear diminution of pliability and elasticity; the wires become harsh and brittle, whereby the rope is weakened. Though the deterioration is generally accompanied by unmistakable external indications, it is yet desirable to trace its progress by actual tests of the individual wires or of the end of the rope itself.

Large diameters for drums and pulleys are of more importance for wire ropes than for hemp, and for steel than for iron. The smallest diameter should be at least 1300–1400 times that of the iron wire in a rope, and 2000 times that of the steel wire. Its relation to the size of the rope itself matters less, because the disadvantage of too small a diameter can be obviated by selecting a suitable size of wire and by a suitable make of rope. It is well, however, for the smallest diameter of pulley or drum to be not less than 80–100 times the diameter or thickness of the wire rope, and 50 times for a hemp rope.

The rope should wind smooth on the drums or pulleys without rubbing sideways against them, and so as to run free from jolts and flapping. For wire ropes it is desirable to line the grooves of the

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pulleys with wood. The larger the diameter of the head-gear pulley the less does it matter how small be the angle which the inclined span winding on the drum makes with the rope hanging down the pit; but with smaller diameters of pulley the angle should be increased, in order thereby to diminish the bending of the rope in passing over the pulley. Opinions differ as to the minimum angle to be allowed. Some assign 40° as the limit, while according to others it should never be less than 60°. In plan, the obliquity of a round rope between the overhead pulley and the drum should always be kept within the smallest possible limits.

In doubling back the rope end for attaching it to the cage, the loop should be kept as large as possible by inserting within it an iron eye or a wooden disc; this is particularly advisable with iron wire ropes, and still more so with steel. The attachment should also be made with springs, for easing the jerk at starting.

Iron or steel wire ropes of large size should not work at more than one-tenth of their breaking strength; small round ropes may be worked up to one-sixth; well-made aloes ropes may be loaded to one-seventh or one-eighth.

Careful maintenance is indispensable to the preservation of all ropes, especially of wire ropes. Hemp ropes need tallowing regularly, and aloes ropes need to be kept always damped. Wire ropes, steel particularly, should be greased regularly, and often enough to prevent their ever beginning to rust. The grease should be soft enough to work into the strands right through the hemp cores, but stiff enough to stick on the outside of the rope. A mixture of oil and grease, well stirred and laid on hot with a brush, answers very well; both oil and grease should be neutral.

Iron wire ropes are rapidly being replaced by steel wire, owing to the less weight needed to afford the same strength. But it must be remembered that when the mine water contains much acid the steel will wear much faster than the iron.

The softer kinds of steel, which contain least carbon, approach wrought-iron in character, having equal toughness, greater strength, and the same capacity of welding. The mildest steels contain 0.15–0.4 per cent. of carbon, and the hardest 1.4–1.6 per cent. The following are the breaking strains per square inch of wire of some of the most usual varieties employed in rope-making, as given by Frecheville:

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| | Tons. |
|---|---|
| Mild steel, | from 40 to 50 |
| Best crucible steel, | " 50 to 60 |
| Best patent steel, | " 70 to 80 |
| Best plough steel, | " 110 to 120 |

Too great stress cannot be laid upon the necessity of having ropes constructed of the best material. The selection of the material, however, somewhat depends on the conditions of working. Thus, with a perpendicular shaft and large drums and pulleys, a plough-steel wire rope will be found the most reliable; but with small drums and pulleys, and a shaft with angles in it, a rope made of best patent steel, or mild steel, will last longer, as the wires are not so apt to snap in bending. In describing a wire rope, the number of strands, the number of wires in each strand, their gauge, their quality of metal, and the material of which the centre or core is composed, should be specified.

As to the gauge—since the ultimate strength of wire increases as its diameter decreases, and since small wires are more pliable than large ones, it would seem that the finer the wire used the better; but there is a practical limit to this, as very fine wire offers too much surface for oxidation, and is too easily injured by friction. Experience has shown that it is advisable to employ medium-sized wires, between Nos. 10 and 15 of the Birmingham wire gauge.

For ordinary work, hemp cores or centres have been proved the best; they stretch with the strands, allow the wires to bed themselves solidly, and give ropes greater flexibility than could be obtained with wire centres. The latter have not given very satisfactory results in practice, although a greater breaking strain is obtained with a relatively smaller rope.

There are many modifications in the methods of laying or twisting the wires.

Common laid rope often has six strands, with seven wires in each, the size of the wire being altered to suit the size of the rope. Compound ropes (that is, ropes with more wires in the strands than the usual construction, in addition to other varieties) have six strands with nineteen equal-sized wires in each, or seven strands with six wires of about fifteen gauge in the middle and twelve round the outside alternately fifteen gauge and twelve; ropes with six strands of eleven, twelve and thirteen wires each are frequently

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manufactured. Some makers prefer the inner wires of each strand smaller, so as to be more flexible than the outer. Six strands in a rope are better than four or five, as they make it more cylindrical and consequently the friction is better distributed. Six strands of nineteen wires each make very durable ropes; these work better than one of equal size composed of six or seven wires in a strand; as the latter, being larger and less pliable, are more liable to snap in bending round pulleys and drums. When three or four of these large wires break near together the rope is hardly fit for work, whereas the breakage of that number of small wires would be of much less consequence. More material can be got into the same sized rope when compound instead of common laid, as the smaller wires do not leave so much space between.

On account of the many different varieties of steel wire employed in the manufacture of ropes, and the varying size of the hemp centres, and the empty spaces above referred to, it is impossible to state a formula for determining the dimensions of a steel wire rope required to bear a given strain. As the nature of a wire rope, however, is defined by number and size of the wires, it is easy, if we know the section and weight per fathom of the gauge employed, to determine the effective sectional area of the rope and its weight per fathom; given, then, the quality of the metal, the breaking strain of the rope can be approximately estimated.

The following table by Frecheville, in which the numbers of the Birmingham wire gauge most usually employed in the construction of mine rope are compared with inches, and the weight of a cubic foot of steel is taken at 487 lbs., will be found useful in these calculations:

| No. B. W. G. | Diameter in inches. | Sectional area in square inches. | Weight per fathom in lbs. |
|---|---|---|---|
| 10 | .137 | .01474 | .2990 |
| 11 | .125 | .01227 | .2489 |
| 12 | .109 | .00933 | .1893 |
| 13 | .095 | .00708 | .1436 |
| 14 | .083 | .00541 | .1097 |
| 15 | .072 | .00407 | .0825 |



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Thus, in the case of a steel wire rope composed of six strands, seven wires in each, of ten gauge, the effective sectional area will be 6 x 7 x .01474 = .61908 square inches, and its weight per fathom in metal 6 x 7 x .2990 = 12.55 lbs. If best plough steel wire, with a breaking strain of 120 tons per square inch, was employed in its manufacture, then .61908, the effective sectional area, x 120 tons = 74.28 tons, and deducting one-eighth for lay, we obtain 65 tons as about the breaking strain of the rope.

Again, let us suppose a compound rope made of the best patent steel wire, with breaking strain of 75 tons per square inch, and composed of six strands of nineteen wires each, thirteen gauge. The following calculation—6 x 19 x .00708, sectional area of each wire, x 75 tons, breaking strain per square inch of wire, less one-eighth for lay, gives 52.97 tons as the approximate breaking strain of the rope. Such a rope with hemp core and fairly made would weigh about 18 pounds per fathom, and have a circumference of about 4½ inches. The actual breaking strain, however, can only be found out by testing sample lengths of the finished ropes.

As the operations of manufacture introduce so many elements of uncertainty in wire ropes, it is well to allow a wide margin of safety—especially where their breakage would endanger life—and take the working load as one-tenth of the ultimate strength or breaking strain. The weight of the rope hanging over the pulley at the poppet-heads is, of course, included in the working load. In very deep mines this weight, even with steel wire ropes, becomes a matter of such serious consideration that tapering ropes have to be used. In the case of a rope working at a very slow speed, such, for instance, as a capstan rope, a larger factor of safety than one-tenth may be adopted. Since any extra strain on a rope leaves it weaker than it was before, on no account should a rope used for raising men be ever worked above its fair working load. In drawing mineral in Cornwall, the custom is to let the skip down on a "gate" put across the shaft. Probably the greatest strain the rope has to bear is when the full skip is lifted. Experiments made at some coal mines prove that when the full cage is lifted from the bottom about double the ordinary strain due to the load is produced. This arises from the inertia of the mass to be moved. In the case of a skip resting on a "gate," the more slack chain there is the greater will be the strain on the rope at starting.

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In winding men there should be no resting-place for the cage; the engine should be started gently, driven regularly, and with a speed of only about two-thirds of what is otherwise usual. The rope also should be examined every twenty-four hours, and this should be done by winding it slowly through the operator's hands; if he does not happen to see the broken wires in all probability he will feel them. Occasionally the rope should be thoroughly cleaned, and its condition more minutely ascertained. When broken wires are found, the longest may be tucked underneath, and the others cut off, to prevent their catching and doing further mischief. A new rope should be tested with several days' winding before men's lives are trusted to it.

It is indispensable for the preservation of steel wire ropes that they should be greased regularly. The grease used should be perfectly free from acid, and soft enough to work into the strands right through to the hemp core. It must not be of such a nature as to harden, for in that condition it allows rust to form between it and the wire, so that a rope that appears to be well greased may be corroded to a sensible depth. A mixture of Stockholm or Archangel tar, a vegetable oil, and a little lime boiled together is often recommended. In Cornwall the tar is generally mixed with tallow. These mixtures, however, form too stiff a grease, tend to hide defects, and render the thorough examination of the rope difficult. A mixture containing gas tar is still more objectionable. Of all the lubricants for wire ropes the best is mineral oil. Some of the heavy mineral oils, such, for instance, as the Russian (their specific gravity being higher than the American), possess sufficient viscosity to be used as a lubricant for wire ropes, and will, if tried, owing to their freedom from acid and power of resisting decomposition, be found to give satisfactory results. At the Wearmouth Colliery they have a patented apparatus, consisting of a pair of wire brushes for cleaning the ropes, and a pair of strong hair brushes fed with lubricant from feeders above, for oiling them. Both sets of brushes revolve, being actuated by the travelling rope. It is claimed that this arrangement lubricates very thoroughly, and effects a great saving of oil and labor.

When a rope is used for winding men, the shackle should be cut off regularly every two to three months, the rope thoroughly examined, and the shackle reset. This is a point of vital importance for wire ropes. In order to arrive at economical results with wire

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ropes, accurate accounts should be kept of their working; by this means the kind most suitable may be ascertained, and a considerable saving effected by using an article best adapted for the purpose. However well a rope may seem to be lasting, it should always be suspected as soon as its duration approaches the average that corresponds with the conditions under which it is working. It should, at any rate, cease to be used where human life depends on it. Owing to trade competition there is great danger of inferior metal being used in the manufacture of ropes, so that when a new one is required only the best makers should be applied to, and they should be furnished with full information as to the conditions under which it has to work. There can be no greater false economy than choosing a cheap rope. When a rope is for the purpose of winding men it would be advisable to have a sample piece of it (say, a length of 10 or 12 feet) tested before use, in order to see that the quality of the metal and the breaking strain are as represented.

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## THE CHARACTERISTIC FEATURES OF THE FRANKFURT ELECTRICAL EXHIBITION.

PROFESSOR W. P. TROWBRIDGE,
*Engineering Department, School of Mines, Columbia College.*

DEAR SIR,—Please accept the following report which I wrote at your request. I took the liberty of inserting a short essay on "The Theory of Polyphasal Current Systems." In view of the fact that the subject of polyphasal generators is very new, and that, therefore, there is but very little in the electrical literature to aid us in the study of this exceedingly interesting department of electrical engineering, I thought that the insertion of the above-mentioned essay would prove useful. We are both under great obligations to Mr. Freedman, John Tyndall Fellow of our college, for the pains which he has taken in preparing the diagrams contained in this report.

Very respectfully,
M. I. PUPIN.

THE work of the historian of the *Science of Electrotechnics* is to a great extent already done in the official reports of the various electrical exhibitions. Each one of these reports contains a carefully prepared account of all the advances in electrotechnics

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accomplished since the preceding exhibition. The future historian of electrotechnics will not fail to observe in his study of these reports that each electrical exhibition had its characteristic features, which were but the reflections of the characteristic features of the science of electrotechnics at that time. A mere glance at the electrical exhibitions of the last forty years will convince us of the truth of this statement.

The London Exhibition of 1851 shows the exhibits relating to telegraphy as the only remarkable practical electrical exhibits. The London Exhibition of 1862 showed but a slight advance in this line. The Paris Exposition of 1867 boasts of the first public exhibition of a dynamo-electric machine. (The dynamo-electric principle was first clearly announced by Dr. W. Siemens, of Berlin, on January 17, 1867.) The Vienna Exposition of 1873 was the first at which large dynamos were shown in actual operation of producing light and performing other kinds of useful work. These were the machines of Siemens, of Berlin, and of Gramme, the well known Belgian engineer. The electrical exhibits of the Centennial Exposition in 1876 are to a considerable extent but a repetition of those of Vienna. There was, however, one exhibit whose importance was not fully recognized at that time; it was Alexander Bell's telephone. The Paris Exposition of 1878 first demonstrated the superior power of the new science, the science of electrotechnics. There was a complete electric lighting plant; the lamps employed were the so-called Jablochkoff candles. The telephone, exhibited here, was no longer a mere squeaking electrical curiosity, but a perfectly operating physical apparatus, whose practical importance was evident to everybody. The Paris Electrical Exposition of 1881 was a magnificent affair. There were over a thousand exhibitors, and among them some of the greatest inventors of the century, as, for instance, Edison, Bell, Siemens, Sir W. Thomson, Gramme, Brush, etc. The practical applications of electricity were shown on a huge scale, especially those relating to electric lighting and electric deposition of metals. Edison's system of incandescent lighting, and Bell's system of telephony were the characteristic features of the exhibition. Other electrical exhibitions followed in rapid succession; suffice it to mention only the Electrical Expositions of London (1881), Munich (1882), Vienna (1883), Turin (1884), London Inventories (1885), Philadelphia (1888), Berlin (1889), Paris Exposition (1889), Edinburgh

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(1890). Every one of these had its characteristic features in the form of some important advances, whose practical value was tested there publicly for the first time. Among these important advances suffice it to mention the *storage of electrical energy, electric railways, electric propulsion of steamboats, electric transmission of power, transformation, on a large scale, of electrical energy from high tension to low tension, and vice versa, utilization of alternating currents for lighting, etc.*

The interesting and very important question arises now: What are the characteristic features of the Frankfurt Electrical Exhibition? In other words, what new information will the future historian of electrotechnics gain from the official records of the Frankfurt Electrical Exhibition?

The answer to this question seems plain to every intelligent observer who has had the rare good fortune of visiting the exhibition and feasting, intellectually, upon the goodly products exhibited there by the science of electrotechnics. The various exhibits were arranged in such a way that one could obtain almost at a glance a complete survey of all the applications of electricity in any one of the various departments of applied sciences and arts, as architecture, civil engineering, mechanical engineering, chemistry and metallurgy, sanitary engineering, mining engineering, dentistry, surgery and therapeutics, naval and military science. Looking upon these exhibits, one could not help seeing in his imagination the *vigorous young science of electrotechnics*, like an ardent and ambitious youth, strong in arm and quick in limb, with broad shoulders and manly chest, with healthy cheek and luminous eye, with sleeves rolled up and the loins girded for arduous work, *a ready, willing, and indispensable assistant of all the older sciences;* and more than a mere assistant, a genial companion whose very presence encourages them to new efforts and to new spheres of action. One can therefore safely assume that *the success of the Frankfurt Exhibition in representing electrotechnics as a very important factor in all technical sciences, will be considered by the future historian of electrotechnics as one of the characteristic features of the exhibition.* This success was in a great measure due to the men, also, who displayed a particular interest for the exhibition, for they were by no means limited to the electrical profession. Every engineering and scientific profession was well represented there; to prove this, one has only to refer to the list of officers and members of the exhibition,

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and also to the men whom one had the pleasure of meeting at the Electrical Congress. In discussing at this congress the question of what the training of an electrical engineer should be, W. von Siemens, of Berlin, spoke as if he had been inspired by this characteristic feature of the exhibition, for his opinion was that *every scientific profession needed a thorough training in electrotechnics, and especially in those parts which have a direct bearing upon each particular profession, whereas additional efforts in higher scientific pursuits and a life-long practical experience may finally succeed in producing what is usually called an electrical expert.* Whose opinion on this point is more valuable than that of W. von Siemens, of Berlin?

The second characteristic feature of the Frankfurt Exhibition was the size of the electrical generators and their coupling to the steam-engine. Rope and belt transmission looked very much out of place, so numerous were the generators with direct coupling to the steam engine. This is especially true of the larger type of generator, as, for instance, the 600-horse power alternating current generators of Siemens, and the generators of the electric company "Helios," of Frankfurt, etc. It seems proper to mention here that the writer saw at the great Deptford electric light station, near London, the completed parts of what he was told to be a future 10,000-horse power (!) alternating current generator of the Ferranti type, which is also to have a direct coupling. Considering that only nine years ago the largest dynamo at the Munich Electrical Exposition was an Edison dynamo of about 25-horse power, one cannot help marvelling at the wonderful success of the science of electrotechnics.

It seems needless to observe that this direct coupling of the generator to the steam-engine has called into existence new and very superior types of steam-engines.

The third and most important characteristic feature of the Frankfurt Electrical Exposition was the Lauffen-Frankfurt Transmission of about 300-horse power of electrical energy over a distance of 175 kilometers (about 115 miles) through what one may call ordinary telegraph wires. This part of the exhibition was a huge experiment to demonstrate before the anxious eye of the scientific world that the alternating or wave form of the electrical currents can accomplish easily what engineers sought in vain to accomplish by the direct electrical current. In view of the eminent economic

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and scientific importance which is attached to this latest advance

FIG 1

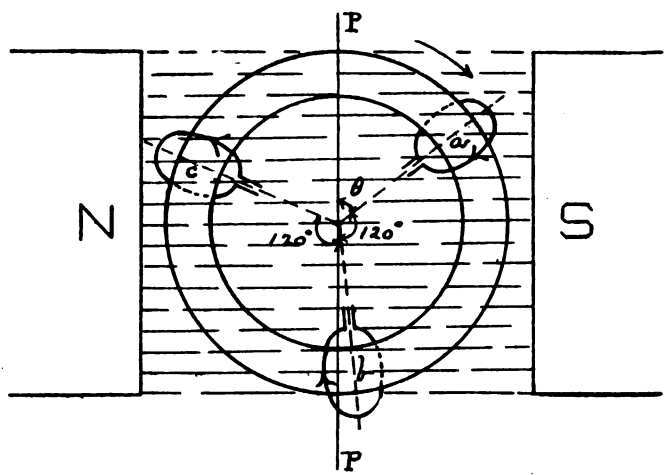
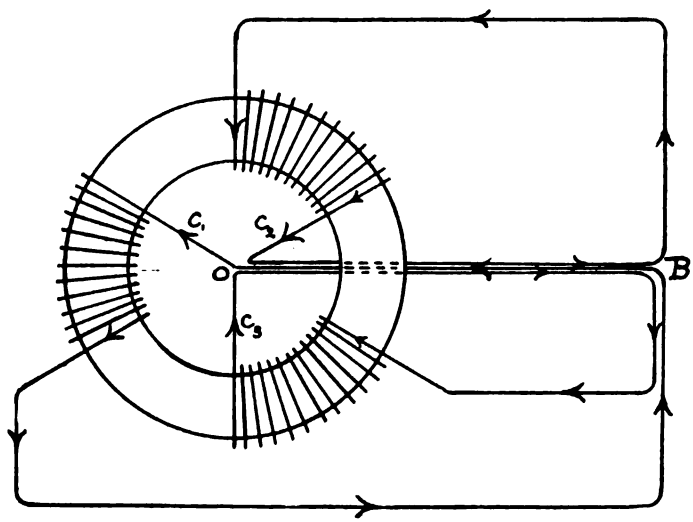



FIG 2




in the science of electrotechnics it seems proper to give a more detailed account of this feature of the Frankfurt exhibition.

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## Theory of the Three-Phase System of Alternating Currents.

A brief explanation of the invention to which the above-mentioned success is due will not be out of place here.

Fig. 1 represents a ring which rotates uniformly in the field of force of the magnet NS, a, b, c, are three equal turns of wire wound around the ring at angular distances of 120° apart. For the sake of simplicity assume the magnetic field to be uniform and the ring made of a non-magnetic material, say wood. Call the plane through PP′ perpendicular to the field the plane of symmetry.

Consider the loop "a" when it is at the angular distance $\theta$ from the plane of symmetry.

Let $M$ = intensity of the field.
$A$ = area of the loop.
$N$ = number of lines of force passing through the loop.
$w$ = angular velocity of rotation.

It is evident that at the angular distance $\theta$

$$N = MA \cos \theta.$$

Electromotive force generated in the loop "a" at the moment t, where $\theta = wt$

$$\frac{dN}{dt} = e_1 = \frac{d}{dt}(MA \cos \theta) = K \sin \theta$$

where K is a constant.

The electromotive forces in "b" and "c" at the same moment t will be, respectively,

$$e_2 = K \sin (\theta + 120)$$
$$e_3 = K \sin (\theta + 240).$$

Since $\sin \theta + \sin (\theta + 120) + \sin (\theta + 240) = 0$ it follows that

$$e_1 + e_2 + e_3 = o.$$

Now two loops are always on the same side of the plane of symmetry, hence the electromotive forces generated in them will have

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the same sign; their sum with opposite sign will be equal to the electromotive force in the 3d loop. In Fig. 1 $e_1$ and $e_2$ have the same sign at the moment t whereas $e_3$ has the opposite sign and is numerically equal to $e_1 + e_2$.

Add now to "a" n more turns all connected in series so as to form an open coil. Let $\alpha$ be the angle between two consecutive turns. Let $e_1, e_2 \ldots e_n$ be the electromotive forces generated in the turns 1, 2, 3, . . . . n.

It is evident that

$$e_1 = K \sin \theta$$
$$e_2 = K \sin (\theta + \alpha)$$
$$\ldots\ldots\ldots\ldots$$
$$e_n = K \sin (\theta + [n-1]\alpha.$$

The resultant electromotive force in this coil $a$ will be $E_1$, where $E_1 = e_1 + e_2 + \ldots + e_n$.

It follows, therefore, from a well known formula in trigonometry that

$$E_1 = \frac{K \sin \left\{ \theta + \frac{n-1}{2}\alpha \right\} \sin \frac{n\alpha}{2}}{\sin \frac{\alpha}{2}} = E_0 \sin (\theta + \beta)$$

where $E_0$ and $\beta$ are constants.

The electromotive force generated in the coil $a$ is, therefore, a simple sine function, or to use a more technical expression, it is a *simple harmonic.*

Add now the same number of equal and similarly placed turns to "b" and "a" and we shall have three equal and similarly placed open coils.

Let $E_2$ denote the electromotive force in coil 2 and $E_3$ that in coil 3. It is easily seen that

$$E_2 = E_0 \sin (\theta + \beta + 120°)$$
$$E_3 = E_0 \sin (\theta + \beta + 240°).$$

Therefore at every moment

$$E_1 + E_2 + E_3 = o.$$

The three electromotive forces differ from each other in phase by 120°.

Take now three equal lengths of the same wire and close each

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coil, by one of these wires. Currents $C_1$, $C_2$ and $C_3$ will now circulate in each coil. The following well-known relations will hold:

$$C_1 = \frac{E_0}{I} \sin(\theta + \beta - \varphi)$$

$$C_2 = \frac{E_0}{I} \sin(\theta + \beta + 120 - \varphi)$$

$$C_3 = \frac{E_0}{I} \sin(\theta + \beta + 240 - \varphi).$$

Where I is the impedance and $\varphi$ the angle of lag in each circuit.

The relation

$$C_1 + C_2 + C_3 = o$$

holds, therefore, for the currents as well as for the impressed electromotive forces $E_1$, $E_2$, $E_3$.

It is evident that any ordinary continuous-current dynamo *which has a uniform effective field* can be transformed into a three-phase dynamo by dividing the armature turns into 3 equal parts and treating each part as a separate circuit.

We shall show now that the 3 separate circuits can be so connected as to save quite a considerable amount of the connecting wire.

Consider Fig. 2. The three coils and the three circuits are given. Since $C_1 + C_2 + C_3 = o$ it is evident that the three wires joined into one from o to B would have no current at all in the junction OB which is common to all the 3 circuits. We can therefore cut it away without changing anything at all in the distribution of the currents. One coil in this method of connecting serves always as a return wire for the other two coils.

Let us go a step farther as indicated by diagram Fig. 3. In this figure let the wooden ring A carry the 3 generating coils whereas ring B is made of laminated soft iron and carries three equal coils distributed over the ring at angular distances of 120°.

It is evident that the introduction of the three coils B into the three-wire system of the generating machine A will change the amplitude and the phase of the three currents, but these two changes will be the same for each current, so that if the values of the three currents be denoted now by $C_1'$, $C_2'$, $C_3'$ we shall have again

$$C_1' + C_2' + C_3' = o.$$

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FIG 3

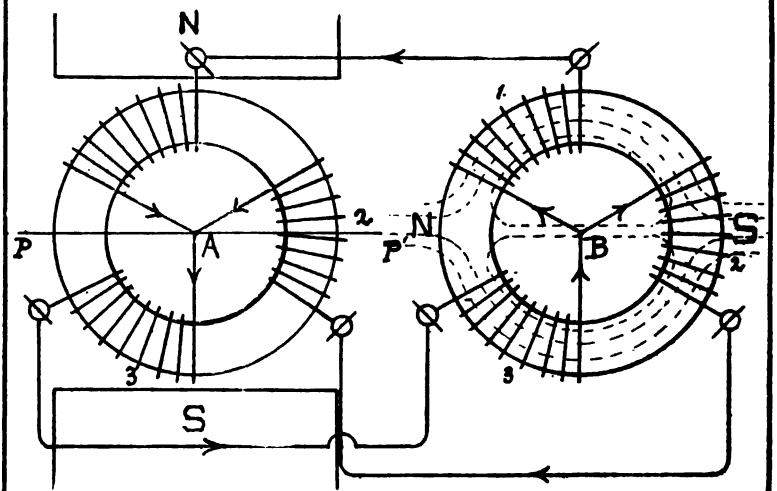
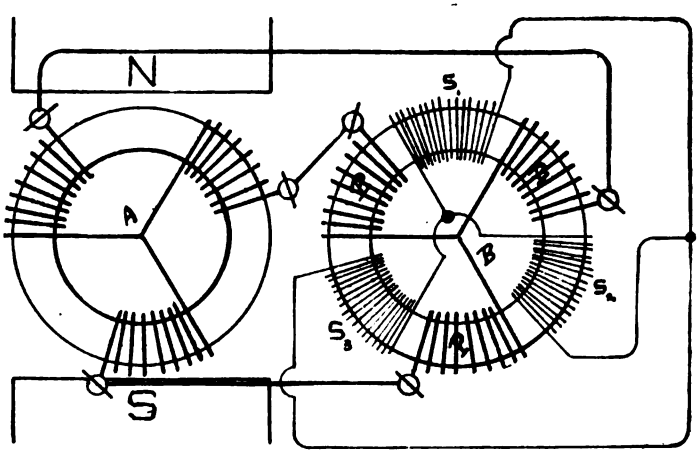



FIG 4




Let the number of turns in each coil of the ring B, Fig. 3, be m, then

$$mC_1' + mC_2' + mC_3' = o.$$

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That is the number of ampère turns of one coil is always equal to sum of the ampère turns of the remaining two coils with the reversed sign. Therefore the iron ring will at any specified moment be magnetized as if it carried at the extremities of a diameter two equal coils joined in multiple arc through which equal currents circulate. The magnetization is indicated in the diagram by the dotted lines. N and S mark the position of the poles at any moment.

A simple consideration will show us that the poles N and S in the ring B will rotate synchronously with the generating armature A.

Let us go back to Fig. 3. Since the ampère turns on one side of the plane of symmetry PP′ are always equal to the ampère turns on the other side of this plane, it follows that the magnetization due to the armature current will remain fixed in space, just as in the case of the ordinary continuous-current dynamo. That is, the magnetic field due to the armature current rotates *relatively* to the armature, with the same angular velocity with which the armature rotates around its axis. But, since the distribution of the ampère turns around the rotating armature ring A is the same as around the *stationary ring* B, it follows that the magnetic field of B rotates in space synchronously with the generating armature A. If we now add to the ring B three equal coils, $S_1$, $S_2$, $S_3$, at angular distances of 120°, and connect them as indicated in Fig. 4, then the system $S_1$, $S_2$, $S_3$, will also be a three-phase system, the difference in the three phases being again 120°. According as the number of turns in $S_1$, $S_2$, $S_3$, is greater or smaller than the number of turns in the primary coils, the ring B will be an up or a down three-phase system transformer. Suppose that it is an up-transformer, then, by adding another down-transformer C, as indicated in Fig. 5, we can transform the current down, and finally send it at low tension into a coil D, which is the armature of a machine resembling the generator A in every respect, except that instead of the pole-pieces, N S, indicated in the diagram, there is a laminated soft iron ring covered uniformly all over with a great many turns of copper wire. The rotating field induces strong currents in these turns, and these currents will, according to Lenz's law, oppose the motion of the rotating field. Consequently, there is a pull between the armature and the ring, and whichever is free to move will move, and perform mechanical

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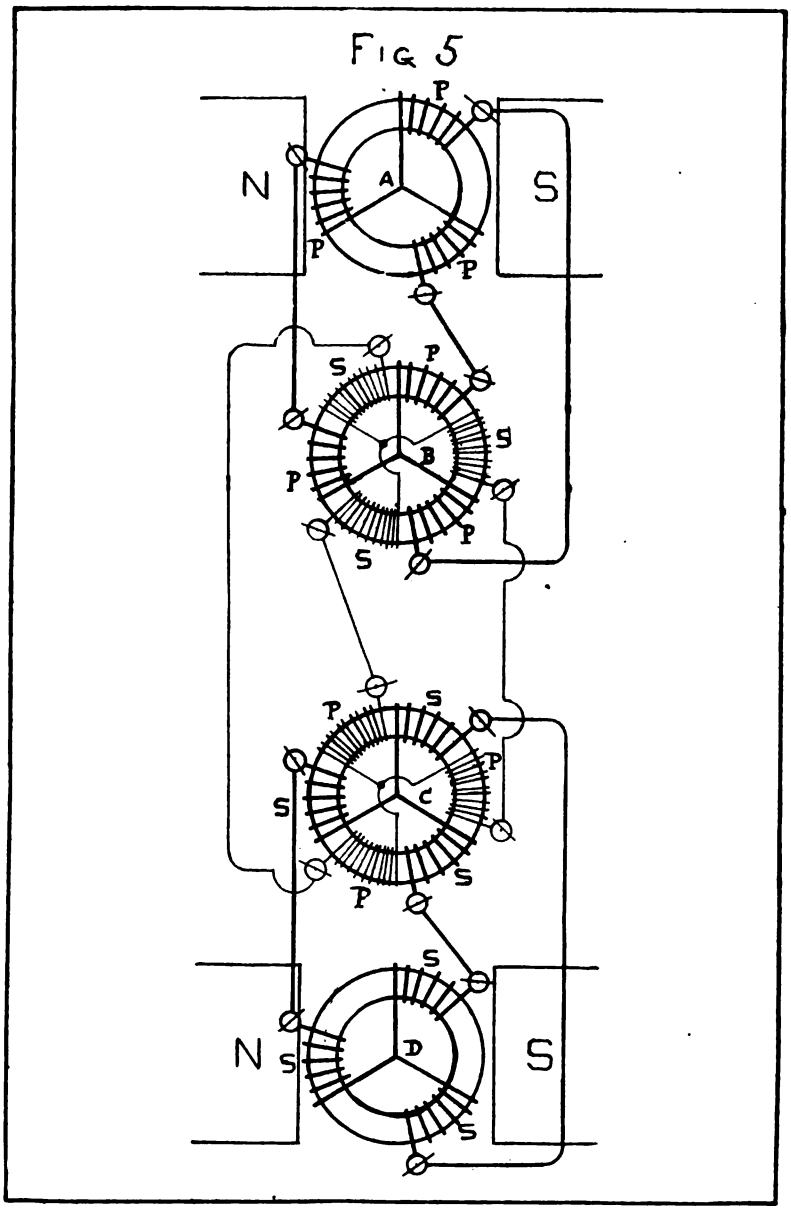
work at the expense of the currents induced in the copper wire surrounding the ring.




Suppose now, that in Fig. 5 A represents the three-phase generator, and B the up-transformer in Lauffen. C is, then, the down-

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transformer, and D the three-phase motor in Frankfurt. There is no attempt made to indicate in these diagrams the actual types of the apparatus used in that famous transmission. They simply appear as the simplest diagrams by means of which the principles involved in the Lauffen-Frankfurt transmission can be explained in an elementary fashion.

There is another point in the theory of this transmission whose importance forbids omitting it from this discussion. It is, namely, the strength of the rotating field of B, in Fig. 3, at any moment.

A simple consideration will show that the strength of this field fluctuates periodically. Let us fix our attention upon the diagram of Fig. 1, and examine the electro-motive forces generated at different moments:

1st Position.—Turn "a" is in the plane of symmetry PP'.

$$E_1 = 0.$$
$$E_2 = E_0 \cos. 30 = \tfrac{1}{2} E_0 \sqrt{3} = .866\, E_0.$$
$$E_3 = -E_0 \cos. 30 = -\tfrac{1}{2} E_0 \sqrt{3} = -.866\, E_0.$$

2d Position.—Turn "a" is at an angular distance of 30° from the plane of symmetry. In passing from position 1 to this position, it is plain that $E_3$ increased continuously; hence, $E_1 + E_2$ increased continuously. In the position 2, $E_3$ becomes a maximum, and so does $E_1 + E_2$:

$$E_1 = E_0 \cos. 60 = \tfrac{1}{2} E_0.$$
$$E_2 = E_0 \cos. 60 = \tfrac{1}{2} E_0.$$
$$E_3 = -E_0.$$

3d Position.—Turn "a" is at angular distance of 60° from the plane PP'. This position is analogous to position 1:

$$E_1 = E_0 \cos. 30 = .866\, E_0.$$
$$E_2 = 0.$$
$$E_3 = -E_0 \cos. 30 = -.866\, E_0.$$

That is, in this position we have a minimum again. This is sufficient to show that the maxima and minima appear periodically at intervals of 30°, as indicated in Fig. 6. There will be six maxima and six minima during each revolution.

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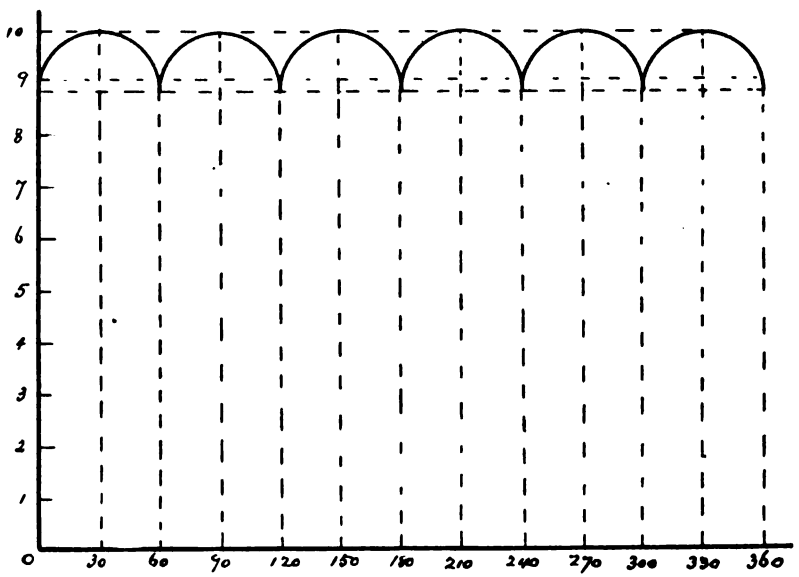
Let us consider, now, another extreme case; that is, the case in which we have three coils instead of the three turns, each coil one-third of the circumference of the ring. Examining now the electro-motor forces, $E_1$, $E_2$, $E_3$, in the three coils in the three preceding positions, we find again the same number of maxima and minima, and the ratio of the minima to the maxima is, as before, .866.

The same process of consideration can now be repeated for the coils as given in Fig. 2, and it will be found that for these coils, also, the same relation holds true. But the currents follow the

FIG 6




same law as the impressed electro-motive forces. Hence, the magneto-motive force in coil B, Fig. 2, and with the magneto-motive force the strength of the rotating magnetic field, fluctuate according to the same law as the impressed electro-motive forces. There are six equal maxima, and six equal minima, in the rotating field, during each complete revolution, the ratio of the minima to the maxima being .866, that is, the maximum variation of the rotating field being nearly 14 per cent. The disadvantages arising from these fluctuations are evident to every electrical engineer, and need no further discussion here.

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The Allgemeine Electricitaets Gesellschaft, of Berlin, which holds the patents on all the improvements in the three-phase system made by Dolivo *v.* Dobrowolsky, claim to be in possession of a three-wire system distribution which reduces these variations to a minimum. If so, then they certainly have made a great step in advance of all the other polyphasal systems of current generation.

The problem of constructing a three-phase dynamo which will produce a rotary magnetic field of constant intensity has not been investigated yet, as far as my own knowledge goes. I find that there are, theoretically speaking, an infinite number of solutions, but that among them there is only one which is of practical value. Dobrowolsky's generator seems to satisfy many of the conditions required by this solution. It is well, therefore, to consider this problem for a moment as a preparatory step toward the discussion of the details of the Lauffen-Frankfurt generator.

Let the equation of the curve in Fig. 7 be

$$y = f(x)$$

Suppose that $f(x)$ fulfills the following conditions:

1st. It is a periodic function of constant period $2\pi$.

2d. $$f(x) + f\left(x + \frac{2\pi}{3}\right) + f(x + \tfrac{4}{3}\pi) = o$$

3d. $$\left\{ f(x) + f(x + \tfrac{2}{3}\pi) + f(x + \tfrac{4}{3}\pi) \right\} = \text{const. numerically.}$$

In a paper communicated to the New York Mathematical Society I showed that $f(x)$ can be represented by the following infinite series:

$$f(x) = a_1 \sin x + a_2 \sin 2x + \ldots\ldots + a_n \sin nx + \ldots \text{ad infin.}$$

in which $a_1$ $a_2$ . . . . $a_n$, etc., are arbitrary constants. That is, $f(x)$ represents a peculiar family of complex harmonics. The first peculiarity is, that none of the multiples like n are divisible by 3. The second peculiarity is exhibited in Fig. 8.

During the first and fifth-third of every period all the curves of this class have a constant ordinate. Every other part of the curve



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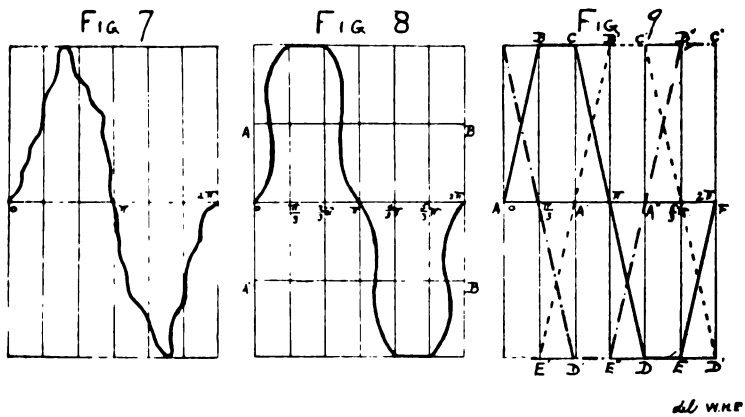
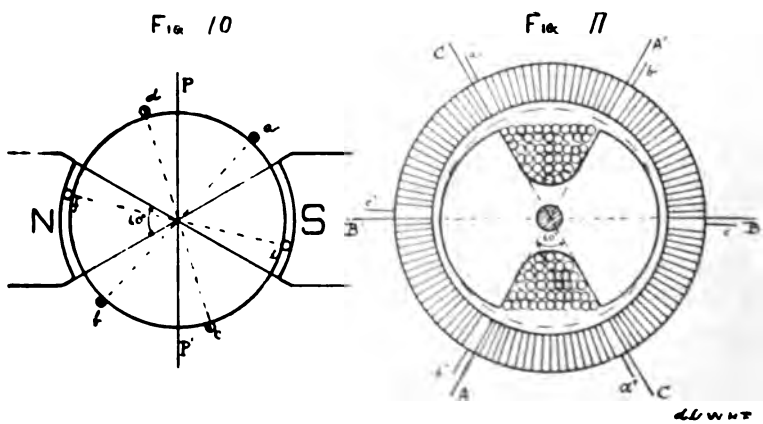
is perfectly symmetrical, both with respect to the axis of x, and in addition to that, the upper halves of these parts are symmetrical with respect to the bisector A B of the maxima of the plus ordinates, the lower halves are symmetrical to the corresponding lower bisector A′ B′.

Among this infinitely numerous family of complex harmonics there is one harmonic which has a superior value in electrical en-




gineering. It is the curve A B C D E F represented in Fig. 9. It is a broken straight line consisting of five parts.

The equation of this curve is

$$y = K\left\{ \frac{\sin x}{1^2} - \frac{1}{5^2}\sin 5x - \frac{1}{7^2}\sin 7x - \frac{1}{11^2}\sin 11x + \ldots . \textit{ad infin.} \right\}$$

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To translate these results from the language of pure mathematics to the language of electrotechnics, consider the magnetic field between the poles N S of a drum armature dynamo. To save tedious repetitions of long sentences, let us introduce a short definition. *The component of magnetic intensity at any point of the surface of the drum armature which is perpendicular to the surface at that point we define as the effective intensity.* Let the effective intensity vary in the following manner: For an angular interval of 60° on each side of the plane of symmetry PP′, let it be proportional to the angular distance from PP′; through the next angular interval of 60° on both sides of PP′ let it be constant, and finally, through the last intervals of 60° on both sides of PP′ let it be proportional to the angular distance from the lower part of PP′. Let, now, three turns of wire, ab, ed, ef, at angular distances of 120° from each other, be stretched over the drum in the ordinary manner. It is evident, then, that the electromotive forces generated in ab, cd and ef by a uniform rotation of the drum will be represented by the complex harmonic curves A B C . . , A′ B′ C′ . . , A″ B″ C″ . . . in Fig. 9. It follows, therefore, that this generator could produce a rotary magnetic field of constant strength.

In Fig. 10 we have the diagram of a stationary ring armature three-phase generator which, with a carefully shaped magnetic circuit, would produce a very nearly constant rotary magnetic field. There are six equal coils; each coil, therefore, occupies one-sixth of the circumference of the ring. The six coils are divided into three pairs by connecting each coil to the diametrically opposed one in series, as indicated in the figure. The ends of the three pairs are connected in the ordinary way of connecting three-phase dynamos. The rotating field-magnet is a solid cylinder minus the excavations on each side and the shavings scraped off from the cylindrical surface of the pole-faces. The cylindrical pole-faces subtend, each an angle of 120° at the centre. Calculation and experiment can certainly succeed in giving to the electromagnet and the air-gap such a shape as to produce not only constant effective magnetic intensity throughout the whole region which at any moment is included between the armature and the cylindrical surface of the rotating field magnet, but also to prevent almost entirely any leakage of the lines of force outside of that

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region,* in which case the electromotive forces developed in the three pairs of coils would be represented very nearly by the three harmonics given in Fig. 9, that is to say, a generator of this kind would produce a rotary field of constant intensity. (The diagram in Fig. 10 should be considered simply as a diagram and not as a carefully prepared design).

We can pass now to the consideration of the Lauffen generator. The characteristic features in its construction seem to be the following:

1. Curiously shaped magnetic circuits, something like figure eight (8) drawn on a skew surface. It is possible to trace them in imagination, but almost impossible to draw them on paper.

The field magnet is constructed in such a way that one and the same coil supplies the magnetizing force for 32 separate magnetic circuits. The coil is placed on a cast-iron disc (*cc*, Fig. 12). Two rings, with 16 pole-pieces each (*aa*, *bb*, Fig. 12) made of soft annealed steel are then attached to the cast-iron disc, and the pole-pieces of the two rings follow each other alternately along the circumference.

The air-space between two consecutive pole-pieces seems to be *exactly* equal to half the breadth of a pole-piece. The air-space between the field and armature is *exceedingly small* for the size of the machine. North and south poles follow each other alternately. The armature is laminated, and the armature windings consist of 96 thick copper bars sunk into the iron of the armature. These 96 bars are divided into three sets. All the bars (those belonging to the same set are similarly marked in the diagram Fig. 13) of the same set are connected in series, following, of course, the well-known rule which is observed in connecting the armature coils of an alternating-current machine.

It is evident that these three sets differ from each other in phase by 120°.

2. The variation of the effective intensity along the circumference of the armature surface seems to follow very nearly the following law: Pass a plane through the axis of the shaft and the median line of a pole-piece. Let this plane rotate gradually until

* Mr. Freedman, John Tyndall Fellow of Columbia College, is preparing a paper on a series of experiments which he carried on during last spring while still a student in the electrical department. These experiments prove conclusively the correctness of the preceding statement.

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it passes through the line midway between the long edge and the median line of the pole-piece. Throughout this interval the effective intensity is constant. From this point on, the effective intensity diminishes proportionally to the angle passed through until the rotary plane reaches the median line of the air space where the

FIG. 12.

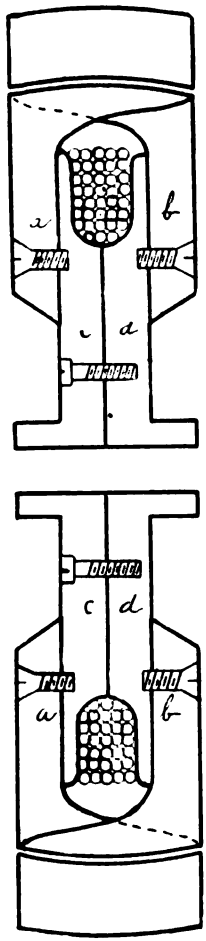
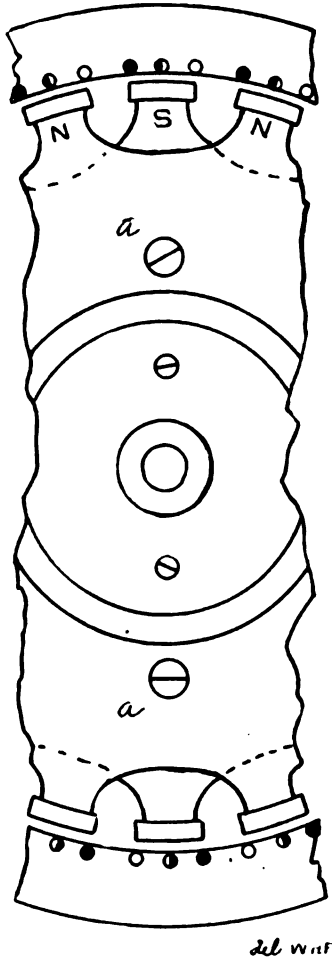



FIG. 13.




effective intensity is zero. From this point on, the effective intensity increases proportionally to the angle passed through until the line midway between the long edge and the median line of the next pole-piece is reached. From this line on, the effective intensity is

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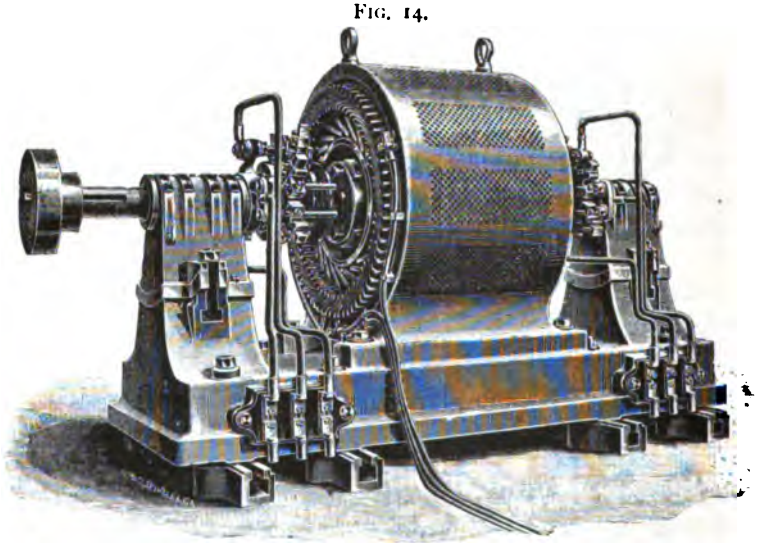
constant again, etc. But if this law be true, then the electromotive forces generated in the three sets of rods are represented by the curves A B C . . . ., A′ B′ C′ . . . . A″ B″ C″ . . . . . Fig. 9, and therefore the rotary magnetic field, which is produced by this generator, will be constant. The field-magnet rotates 150 times around per minute; hence, there are 40 complete waves or 80 reversals per second. The armature of the motor is stationary and of the same construction as that of the generator; but instead of the field-magnet there is in the motor a laminated iron cylinder with copper bars parallel to those of the armature passing

FIG. 14.



Dobrowolsky Motor.

through the iron near the surface of the cylinder. All these bars are connected in multiple arc by means of copper rings. The rotary magnetic field induces very powerful currents in these bars, and thus produces a steady pull upon the laminated cylinder. It is evident, therefore, that this motor will run asynchronously and start with any load within its capacity. The rotary magnetic field being of uniform intensity, all heating and wearing and tearing effects due to magnetic fluctuations are completely avoided, and the motor runs as smoothly and as noiselessly as anybody could wish.

A full description of the machinery employed in this transmission would lead me far beyond the limits of this report. On this

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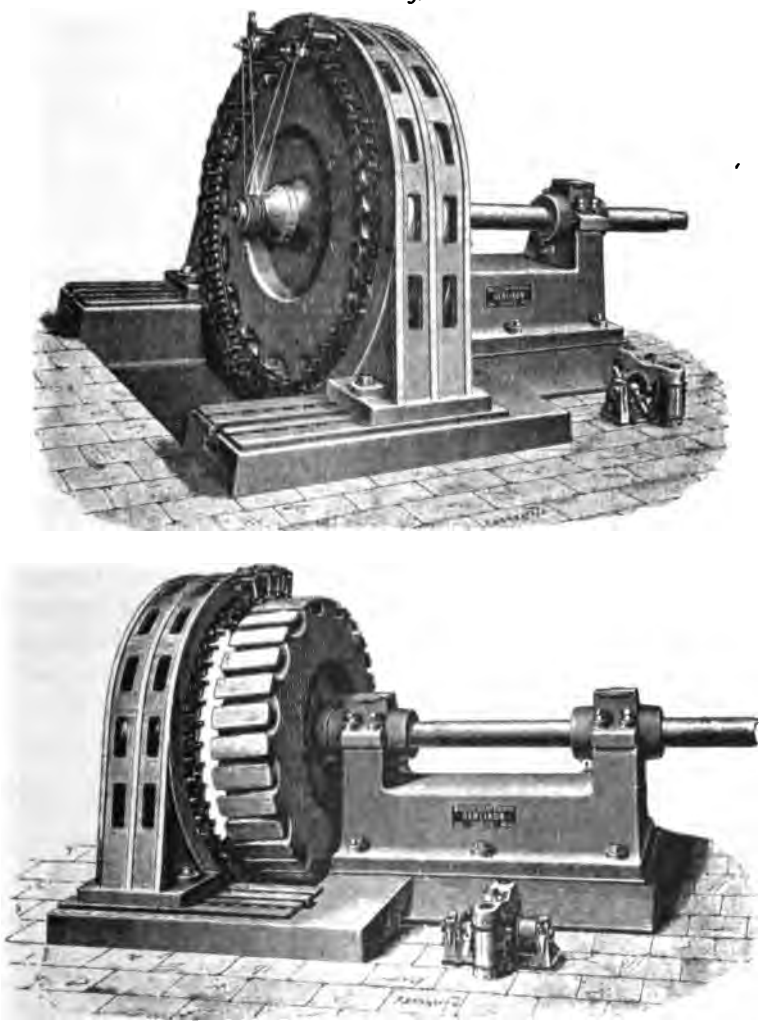
point it seems sufficient to refer to articles which have appeared during the last six months in the New York *Electrical Engineer* and the London *Electrician*.

FIG. 15.



Dobrowolsky-Brown Dynamo.

The author has had the pleasure of a personal inspection of the whole plant, and he is very happy, indeed, in confessing that to him every detail appeared to have been designed by the engineers,

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Dobrowolsky and Brown, and carried out by the Allgemeine Electricitaets Gesellschaft of Berlin, and the Oerlicon Company, with an exceedingly high degree of perfection. The automatic speed-regulation of the turbine-wheel which drives the generator in Lauffen; the generator itself, which, through each one of its three conductor systems, sends an electrical power of 50 volts and 1400 ampères; the transformers at Lauffen, which take up this power and transform it into electrical power of about 20,000 volts, and only a few ampères; the slender bare wire conductors, which, running along thousands of well-insulated poles, carry this power over a distance of about 115 miles to Frankfurt; the transformers in Frankfurt, which take up this high-tension energy and transform it down to only a hundred volts and many hundreds of ampères; the 100-horse-power motor, and the group of a thousand incandescent lamps, between which this 100-volt electrical energy is equally divided; the various devices of controlling, regulating, and distributing the electrical power at every point of the system—all these things remind the careful observer and admirer of the full-armed Minerva springing out of the mighty head of the Olympian Jove.

That eminent English electrician, Professor Sylvanus Thompson, of London, remarked, in an address before the Electrical Congress in Frankfurt, that the Lauffen-Frankfurt transmission *marks an epoch* in this passing century which was so productive of great inventions.

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## HARBOR IMPROVEMENTS ON THE PACIFIC COAST.

By FRANCIS X. BROSNAN.

THE length of the Pacific Coast line is about 1400 miles, 900 of which belong to California, 300 to Oregon, and nearly 200 to Washington. It has numerous indentations, but many of these are merely coves, there being only a few naturally formed harbors and protected anchorages. Still a majority of the bays and roadsteads are susceptible of great improvement, and this may be done without that expenditure which the magnitude of the works would seem to imply. Sand accumulations of ages have to be removed and the courses of channels changed, but the construction of a

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simple sea-wall can compel the ocean to undo its work and divert currents in such a way that permanence of depth can be effectually secured where needed.

Serious difficulties are experienced in the construction of breakwaters on the northern part of the coast. The force of the waves is enormous, and although the name Pacific would seem to contradict this, it is a well attested fact that seldom along any shore does the sea attain such violence. The storms off southern California are not so severe as those that occur on its northern coast, or on that of Oregon and Washington. The latter often last for weeks; the former are generally spent in a few days. And indeed not only in stormy weather, but at all times is the sea below San Francisco quieter than it is above. The figure of the coast line alone would indicate this.

It will be seen, then, that this part of the coast is broken and that its trend is not continuous. It would be otherwise if the waves had the strength that they possess in the northern Pacific. They would wear away indentations, except in a few places, and tend to make the line of the coast less deviating. The reason why the waves are not so violent here is that the winds sweeping down the coast do not keep to the shore as this retreats, but continue on their course. South of the Columbia river, where the sea has such force, there is a straight coast for several hundred miles. Hence it is, that in considering the question of a harbor of refuge, the Southern Pacific has not been examined at all, while the Northern Pacific coast has been made the subject of much study and inspection.

From San Francisco to Point Reyes, the coast is bold and high, then its altitude decreases somewhat up to Point Arena, where it becomes greater, and reaches 2000–3000 feet. After the stretch of sand, 15 miles long, that separates Humboldt Bay from the Pacific, the shore again becomes elevated and continues thus up to Point Orford. Sand spits and rocks occur at intervals up to Tillamook Bay, and then comes a beach 100 miles in length, broken finally by the mouth of the Columbia river. It is supposed that while the northern extremity of the bay, marking the entrance of the Columbia into the Pacific, was always Cape Disappointment, the southern limit was once Tillamook Bay. Not only does the sea tend to straighten the coast, but also the summer northwest winds aid it. When these blow, long tracks of sand

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can be seen flying towards the south, sharp corners are worn away and trees are often found completely buried.

It is fortunate that Washington, Oregon and Northern California have not a lee shore, else the disasters, numerous as they are now, would be very much multiplied.

## San Diego Harbor.

San Diego is one of the most important towns in the southern portion of California. It possesses a fine harbor, which has the advantage of being shut off from the sea by a narrow peninsula, affording an excellent anchorage for vessels. Up to the year 1876, however, it labored under a serious drawback, the result of an extraordinary freshet which took place fifty-one years before. At this time the San Diego river, which is about forty-five miles long, flowed through a very sandy region and finally emptied into a low lagoon called False Bay. The year 1825 was an unusually rainy one, so much so that the river, abandoning its natural bed, turned southward and forced its way into the Bay of San Diego. Year after year it carried down to its mouth a large quantity of sand and threatened to transform the harbor into a flat sand bank. This state of affairs continued until 1876, when the sum of $80,000 was appropriated for the purpose of improving the port.

An examination was made and it was ascertained that no good could be done until the outward flow of sand was checked. For the first six months of the year there was generally a depth of two or three feet of water in the vicinity of San Diego. Then this soaked through the sand, so that water could not be reached except by digging several feet.

The ordinary velocity of the current was one mile an hour, but when heavy seas prevailed a volume of water seven or eight feet deep, and having a velocity of five miles an hour, came out of the river mouth like a torrent. Great quantities of sand were borne down by it and deposited, until they reached a depth of 48½ feet. Before any improvement at all could be made, this flow of sand had to be checked, and, as it seemed inseparable from the stream itself, it was evidently necessary to turn off the San Diego in some other direction. The wisest plan seemed to force it to follow, at least approximately, its old bed, and empty once more into False Bay. The latter was of no use whatever, and consisted of shallow water and sand heaps. After some discussion the following idea was

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adopted and carried out: An artificial water-way was dug from a certain point on the river to a slough which emptied into False Bay; then the channel through which the San Diego had flowed from 1825 to that time was filled up. Lastly there was constructed a levee, 1½ miles long, so as to prevent water from escaping into San Diego harbor. The axis of the embankment is the arc of a circle whose radius is 11,139 feet, the convexity being turned towards the north. Its width at the top is 23 feet; its sides have a slope of 2 to 3, and it is 6 feet in height. It was dressed with cobble-stones, laid dry and rested on a foundation made by digging a trench in the ground and filling this with stones up to the natural surface. The improvement was completed in November, 1877, and has since needed but slight repairs. The levèe was injured somewhat by rain and also by the cattle that found their way over it. The stone revetment was thrown down in certain places, but the damage was readily repaired. There is no doubt that this construction will stand the test of years and keep the San Diego within its ancient limits.

### WILMINGTON HARBOR.

The town of Wilmington is about 90 miles distant from San Diego, and is situated on a small estuary opening into the Pacific Ocean.

The harbor was shut off from the ocean by a long strip of land called Rattlesnake Island, to the south of which were low flats, and beyond these a small space of ground known as Deadman's Island. Rattlesnake Island stood 8 to 10 feet above high water; the flats were bare at low water and rose to a height of 2 or 3 feet, while Deadman's Island, like Rattlesnake, was never submerged. The flats had all the appearance of hard, compact sand, but in reality they were quick-sand. There was a shoal connecting Deadman's Island with the main coast, the water over which was of such little depth that vessels even of a moderate size could not make the passage. Ships had to lie one mile from the bar and three miles from Wilmington, the passengers and freight being transferred to lighters. In many cases the farmers could not export their produce on account of the additional cost of freight.

In the year 1869 Lieutenant-Colonel Williamson was ordered by the Chief of Engineers to make an examination of the harbor, with a view of ascertaining what could be done in the way of improvement. In the first place the shoal had to be removed; and

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then the waters of the bay needed deepening. It was noticed that certain parts of land which were submerged in 1859, when a Coast Survey map was made, were, in 1869, quite out of water. The water, too, was deep in the vicinity of the flats, but where the bottom was unprotected from the open sea it was quite shallow. Everything seemed to suggest that a dam should be built from Rattlesnake Island to Deadman's Island, in order to secure the scouring action of the ebb tide. As it was, the escaping water formed endless eddies and currents which might well be utilized.

The length of the breakwater in the adopted design was 6700 feet. Starting from Rattlesnake Island, the plan was to build 3700 feet of double sheeting piles, driven into the sand and rising one foot above high water. Then there was to come 1000 feet of construction, consisting of two parallel rows of 12-inch piles, 10 feet apart and suitably braced. A portion was to be filled with brush and stone, while the rest was to have no filling at all. The remaining 2000 feet consisted of a wall of stone 10 feet wide at the top, with an exterior slope of 1 to 3 and an interior slope of 1 to 1. The last portion would be more exposed to the open sea; the waves would be stronger and there would be less likelihood of the sands accumulating around it. Timber, then would be unprotected, and would soon be perforated through and through by that little, but active, agent of destruction, the *teredo navalis*.

The work was commenced in October, 1871. The undermining action of the water soon swept away the piles. To counteract this, heaps of brush and small cribs were placed near the wall to deflect the currents. They succeeded in doing so very well. Besides this, the south-eastern winds of winter heaped sand against the work on both sides. The second section of the timber portion was commenced in January, 1872. Six drive-piles were used; one drove the scaffold-piles, ten feet apart; one drove the brace-piles, which were five feet apart, and made an angle of 30° with the vertical. The third put down the uprights, the fourth and fifth placed in position the sheeting piles, while the sixth took up the scaffold as the work was finished. To counteract the effect of eddies, and to favor the accumulation of sand, wings were built, 100 feet apart, at right angles to the wall. These consisted of piling and crib-work, but were not very successful. Any advantage gained in one quarter was lost in another.

The culminating undermining action of the tides was reached in

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July, 1873, when the wall gave way in three places. An aggregate of 360 feet of finished work and 120 feet of wings was swept away by the great currents, which ploughed for themselves channels 25 feet deep. Nature was allowed to take its course; the rents were not repaired completely. They were filled with stone to a depth of 4 feet below low water, on which were placed cribs loaded with stone. Then the breaks were provided with tide-gates, which opened on the flood- but closed on the ebb-tide.

At the end of November, 1873, the 4700 feet composing the timber portion were completed. The storms and currents did not fulfil the expectation of the engineers in regard to their piling sand against the timber. Only 500–600 feet were covered, and at mean low tide the double row of piling stood in 5 feet of water. Quantities of stone and rock were thrown on it, until they reached a height of 3 feet above mean low water. This prevented effectually the attacks of the *teredo*.

On other portions of the work, clay, sand, gravel, and beach-shingle were used. To control the action of the currents, two stone jetties were built; one, 600 feet, the other, 380 feet long; 700 feet of short jetties were also constructed to aid the former in accumulating sand. This took place slowly, but surely, so that, at the end of 1874, there was formed a bank 100 feet wide, and 2500 feet long.

The last part of the sea-wall was built to mean tide level, so as to permit the flood-tide to enter the inner harbor. To secure the scouring action of the ebb, this was allowed as wide a passage as possible. Up to June 30, 1874, 600 feet of the latter portion were entirely finished, 600 feet two-thirds finished and 800 feet one-half finished.

When the breakwater was completed, the question of removing the shoals before mentioned was considered. It was proposed to make a channel 200 feet wide and 10 feet deep at low water. As the bottom near the shoals was composed of hard sand and boulders, it was little affected by the scouring action of the water; still there was now a depth of 4 feet, 2 feet having been gained since the commencement of the work. Surveys were made before the deepening of the channel was begun, and they showed that a depth of 10 feet at low water would give 13–14 feet at high water, and 16 feet at spring tides. This would be sufficient for some years and would do away with the expensive and tedious lighterage.

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Another year's scouring increased the depth of the water to 6 feet; while at the end of the year 1877 over 24,000 cubic yards had been removed.

Meanwhile, Rattlesnake Island was being covered with sand, until it now extended 2500 feet, and had an average width at the top of 250 feet. A creeping sand-plant grew over a large part of it, and its roots rendered the surface stable against the wind.

In regard to the portion of the timber work that was covered with rip-rap, it was found that although the interstices of the works at first permitted the entrance of the *teredo*, these interstices were afterwards filled with sand.

In 1878, there was a channel through the reef of clay and stone at the mouth of the harbor, 150 feet wide, and 12 feet deep at mean low tide. Various expedients were employed to hasten the deposition of sand on the wall. A number of lines of fascines, two tiers deep and 78 feet long, were extended out from the embankment on the seaside. These were placed parallel to the crests of the waves, and in one month were filled to the top with sand. The expense was too great, however, and they were abandoned. On May 10, 1878, the breakwater underwent, successfully, a severe test. A tidal wave flooded the whole construction, and a portion of the adjacent country. The water rose 6.8 feet in 2½ minutes, but did not do any damage.

In 1881, the desired depth of 10 feet was obtained, but it was found that commerce was increasing so rapidly that this would not be sufficient. Operations were continued in the succeeding years, and in 1888, 15 feet of water stood at the entrance near Deadman's Island, where, in 1871, there was only one foot.

### Oakland Harbor.

The city of Oakland is second in population only to San Francisco. It is five miles distant from the latter, and is situated on the estuary of San Antonio, which opens into San Francisco Bay. Before the year 1873, when the present improvements were first projected, foreign and domestic commerce were carried on under great disadvantages. Vessels bearing freight and passengers for Oakland were obliged to stop at a point two miles off, being prevented from approaching nearer by a sand bar, over which the water stood at a depth of merely a few feet. A railroad built on trestle connected the bar with Oakland proper.

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Topographical and hydographic surveys were made with a view of forming some plan of cutting away the bar at the mouth of the estuary, and thereby increasing the depth of the water.

It is a well-known fact that, in works of this kind, the difficulties themselves often suggest means for their overcoming. During the rainy seasons of many years sand had been washed down into the estuary of San Antonio, narrowing its inner end considerably. The tide-water from the neighboring sloughs flowed through the contracted passage and excavated a channel for itself. The estuary increased in area, however, as it approached San Francisco Bay, the velocity of the currents was lost, and the water became very shallow. Inside there was a depth of 18 to 20 feet at low tide; one-half of a mile further out this was reduced to 2 feet. To secure a uniform velocity in the estuary, the engineer in charge proposed building two training walls from Oakland into San Francisco Bay. These would confine the water between them, increase its velocity and cause much of the sand to be borne away by the current. These training walls, according to the plan adopted, would be entirely covered at high water, but would enclose between them the latter part of the ebb tide, which had the most scouring action. As the tide rises it extends over a large area and deposits whatever sand it may carry. If, when it fall, its action is dispersed, this remains and accumulates from year to year; but if the passage of the outflowing tide is narrow, its force is concentrated and it sweeps away all sediments. For another reason, also, was this particularly true at Oakland Harbor. The tides went through a cycle of increase and decrease; a very marked low water was followed by a very small high water. Then there was a large high water, succeeding which was an equally large low water. The ebb tide between the last two periods of very high and very low water acquired so much energy that confined between the training walls it would excavate in a short time a good channel. But, as the necessities of commerce were urgent, this tide was to be assisted in its work by two ways: First, by dredging the channel, and secondly, by connecting the estuary of San Antonio with that of San Leandro, and so enlarging the tidal prism. To effect the latter result, a canal would have to be made through the land between the two basins. The mouth of the latter would have to be closed partially by a dam provided with automatic gates in case the whole of the tide was needed.

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Calculations showed that a channel 1000 feet deep and 18 feet wide could be expected from these improvements. The construction of the jetties was pushed forward; they were made of loose stone obtained from neighboring quarries. The north wall was completed to a length of over 9000 feet, and the south wall to a length of 11,000 feet when, about the middle of the year 1877, operations in Oakland Harbor were discontinued, and were not resumed until three years had passed.

It was found that the impact of the waves tended to demolish the channel side of the walls, and the latter were accordingly raised above high water. Also the wall, when reaching merely to low water, allowed large sediments of sand to pass over it, and was, besides, the cause of dangerous cross-currents. The width of the channel was reduced to 500 feet. The jetties were not increased in length, but considerable dredging was done, so that in 1889 a depth in the channel of 10 feet at mean low water was obtained. On February 18th of that year, ground was broken for the excavation of the tidal canal, and a contract was made for the removal of 600,000 cubic yards of sand, earth, etc.

It was estimated some time ago that thirty years would be necessary to carry out the line of improvements in full, but it only took four years to show how much the jetties benefited the harbor of Oakland. In 1874, when the work was commenced, 154,300 tons of freight were carried to Oakland through the channel; in 1878 this amounted to 340,627 tons, and in 1889 to 2,208,995 tons. The custom duties in the latter year were $9,786,937, over $650,000 greater than in 1888.

## Humboldt Bay.

Humboldt Bay is about 230 miles north of San Francisco. It is separated from the ocean by a bar of varying position and size, and extends in two directions, the northern channel leading to Eureka, a port of entry, and the southerly one flowing 3½ miles into mud flats. The total length from north to south is 14 miles. This harbor is completely land-locked by two spits of sand. The width of the entrance in 1851 was 2200 feet, and the depth at mean low water 21 feet. In 1882 the headlands were over 4000 feet apart, and the sea at mean low water was only 12 feet in depth. From September, 1881, to June, 1882, the north head lost 45 acres, corresponding to a displacement of 1,000,000 cubic yards of sand.

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Similar changes had taken place 23 years previously, but the reefs, by the slow action of the water, returned to their original position and maintained it until the forces opposing their formation suddenly reached a maximum.

The bar at the entrance of the harbor was also affected. In 1859 it was one mile to the south of where it was in 1854, and three-quarters of a mile north of its position in 1880.

It was claimed that the great accumulation of sand in the bay was caused principally by the washings, during the ebb tide, of the numerous streams that flowed through the adjacent sand flats. Some of these deposits also came from the Eel river, 15 miles below. The current along this part of the coast is, in general, a northerly one, but its direction is reversed in summer by the southerly winds which blow so continuously during that season.

In spite of this the channel to Eureka was almost deep enough; and though breakers could generally be seen on the bar, some portion of the water over it was navigable. The channel was too narrow, and subject to changes which were the source of great danger. The variations in the width of the channel were all due to the action of the water on a sand formation called the South Breaker Flats. These encroached on the bar channel just as it rounded the north spit to take its course towards Eureka. When the flats rose above low water they served as a training wall to guide the currents, and as a breakwater to protect the north spit from the erosion of the tides; but when these sands could no longer resist the ocean, there was nothing to keep it from the headlands at the entrance of the harbor. The north one was rapidly worn away; the south spit had a bed of clay, and hence was more permanent in character. It was evident that either the South Breaker Flats should be protected by a revetment, or else that a wall should be built further out, which would deflect the currents from this bank.

In 1882 the Board of Engineers recommended the construction of a low water training wall, running from the south head in a northwesterly direction. Its estimated cost was $600,000. Nothing was done on this until 1888, when the government acquired the right to certain lands on the line of the work. The jetty, as yet incompleted, is made of rock dumped on brush mattresses.

It may possibly have to be carried above high water, as a wall



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built only to low water permits sand to be borne across it, and also does not fully concentrate the tides.

As the velocity of the current depends, comparatively speaking, on the narrowness of the channel, it is of the highest importance to preserve the north spit, either by gabions or by a wall similar to that which runs out from the south spit.

## Coos Bay.

Coos Bay has not inaptly been described as resembling the letter U, with its convexity turned towards the north. When the waters of the Pacific pass the high bluff of Coos Head, they divide themselves into two portions. One part ascends Coos Bay, the other flows in the opposite direction and enters South Slough. The latter is not navigable, as the depth of water rarely exceeds a few feet. The harbor is completely land-locked; in fact, the word "Coos" signifies, in Indian, a lake. It extends notheasterly about seven miles to the apex of the U, and then descends southeasterly about five miles. The depth varies from 15 to 22 feet at low water, and there are in all three bars.

The Coos river, which empties into the bay, is navigable for 20 miles. Without the harbor and a little to the east of Coos Head there is a thin spit of land which reached its maximum length once in five years. The northwest winds of summer increased the spit, by degrees, to the southward, thus forcing the channel close to Coos Head, and narrowing the passage considerably. North of Coos Head there was another sand-bank, which grew towards the north, while the other extended southward. This tended to throw the channel on the west side of the sand-spit. For five years, as it was ascertained, both of these formations grew until the harbor reached its minimum width. Then the waters, confined up to this, burst through the sand-spits and created a passage. The harbor in this condition was of some use, but it did not long remain so, as the accretions commenced anew. One would naturally suppose that the ebb tide exerted a scouring action on this sand-spit; but it did not, owing to the fact that when the tide began to fall it flowed out of Coos Bay in almost directly opposite directions. Endless eddies resulted, and all the force of the ebb was lost.

It was evidently necessary, before any good could be accomplished, that the two currents should be prevented from meeting

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each other, and the sand-spit be checked in its downward growth. Then a greater depth of water over the bar could reasonably be expected. For this purpose it was proposed, in 1879, to build two jetties; one commencing a short distance below Fossil Point, and the other running across the channel parallel to the first. The two, it was estimated, could be built for $972,000—the first alone for $600,000. Plans were then made and adopted for the first wall. It was termed by the engineers in charge a costly experiment, but time has shown it to have been a successful one.

Quite a latitude was given to those who superintended the work. The jetty was to be either of wood and stone, or entirely of stone. The character of the bottom was not known very well, nor the force of the waves, nor the extent to which the *teredo navalis* would attack timber. Examinations showed that a rock, 400 feet in length and reaching to the shore, lay beneath the line of the embankment. Beyond this there was rock covered by a more or less thick coating of sand. As the whole construction was somewhat in the nature of an experiment, it was decided to build it as cheaply as possible, and to use, at least at first, wooden cribs loaded with stone. If everything went on well they could be replaced by rock.

The proposed length of the jetty was 2400 feet. The first crib was sunk in 1880 at a distance of 538 from the shore, the interval having been closed up afterwards. The cribs were 50 feet long, 26 feet wide, and were to project two feet above low water. As they had to be sunk at flood tide, they were made at first somewhat higher than necessary, and were afterwards cut down.

The work progressed slowly. The quarry was 24 miles distant, and great difficulty was experienced from the violence of the currents. The cribs had to be put in place exactly at slack water, an error or delay of a few minutes causing complete failure. The ebb tide was smooth, and all that was necessary to hold the cribs in place was to let down two spuds from the front and secure them by wedges. Thirteen cribs were laid, making an aggregate length of 650 feet.

There was so much trouble in sinking the last crib, on account of the strength of the current, that it was decided to continue the embankment entirely with stone. Meanwhile the inshore interval had first to be built. This was made largely of narrow plank cribs, ballasted with stone, and securedly rip-rapped, extreme

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care being taken to make a good junction with the main timber portion.

Up to 1883 the embankment was in good condition. The borings of the *teredo* were marked, but not such as to endanger the stability of the structure. An increased depth was obtained in the channel, and the north spit was moving very slowly but surely. Everything was now ready for pushing the embankment seaward, and for this purpose a railroad was built on piles driven into the cribs.

A good quarry was discovered near by, and then the work went on expeditiously and without much trouble. Up to June, 1888, the following portions had been completed: The inshore interval of 538 feet, 650 feet of timber cribs, 695 feet of box cribs and stone dump, and 416 feet of stone dump. Also over 3300 feet of stone had been placed in advance of the jetty to serve as a foundation for the succeeding courses of stone and to prevent the bottom of the channel in the line of the embankment from being scoured out.

The channel was considerably improved; it was less shifting in character, and vessels which before had to wait for weeks beyond the bar, could now enter very easily. The sand-spit was noticeably wearing away, and the mouth of the South Slough was being filled.

### Yaquina Bay.

Yaquina Bay is a narrow body of water, 20 miles long, emptying into the Pacific ocean at a point between the middle and northern extremity of the coast of Oregon. Before any improvements were made, the channel at the entrance of the harbor was divided into three channels, called, respectively, the north, middle, and south. This separation was caused by a reef lying a mile from the shore, and a quarter of a mile from the outer edge of the bar. The reef, it is true, served as a natural breakwater, but very often waves passed over it and did great damage to the shore. The northern head of the reef was rocky and permanent; the southern was composed of sand, and was frequently changed in form by the violence of the waves.

The reef, running north and south, gave rise to many shoal areas, especially in the vicinity of the north channel. The beach near the latter was dangerous and difficult to improve. The south channel was also shoal, and so blocked up by rocks that navigation in it was extremely perilous. The middle channel was deeper

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and comparatively free from rocks, though it was supposed that a reef lay beneath it, from the fact that outcrops of rocks were visible on both sides.

It was proposed at first to build a timber cribwork covering the southern channel and to protect the southern shore by some means from erosion. The first crib was put in place with great difficulty. It was sunk at some distance from the land, the idea being to extend the cribwork shoreward.

The currents were so strong that the cribwork had to be abandoned, and instead of it a jetty of stone resting on brush mattresses was commenced from the shore end of the improvement. The jetty at first was to have been two feet above mean low water, but the height afterwards was changed to full high water. The mattresses were constructed of fascines held together by grillages of fir poles, and were two feet thick. Two courses of these, with heavy stone ballast, brought the jetty to high water. The foundation mattresses were 60 feet wide, the upper ones 30 feet wide. When work on the jetty was temporarily suspended, a crib, 30 feet by 50 feet, was attached to its end for the purpose of protecting it.

June 30, 1889, about 3000 feet of the jetty had been completed, and the work of rip-rapping it and raising it to the desired height was in progress. The shore end of the embankment, consisting of a dock, was washed away by the tides, but the jetty itself remained uninjured. The currents were steadily eroding the southern beach of the harbor and causing it to visibly recede. This action was stopped to a considerable degree by placing on it fascine mattresses weighted down with sand bags. The results of the improvements were very encouraging; the southern channel was permanently deflected from its course and united with the middle channel, and the depth of water in the latter was increased from three to four feet. A further beneficial effect was observed. The increased velocity and volume in the channel lessened somewhat the width of the bar and forced it seaward.

In 1888 a plan of further improvement was suggested which would very much enhance the value of the harbor. This was the building of another jetty extending from the north head and running parallel to the south jetty. There would be a width of 1000 feet between these which would afford a good channel and ample space for the anchorage of vessels. Besides this, the elevation of the old jetty to high water was contemplated, as at present large

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quantities of sand were carried to and fro by the ebb and flow of the tide.

### The Mouth of the Columbia River.

The Columbia is the most important river in the Pacific region. It is navigable for a distance of, at least, 150 miles from its mouth and forms at its entrance into the ocean, a capacious harbor six miles wide and ten miles long. Up to 1884, however, it was almost entirely closed in by sand banks and sand bars, which offered a formidable obstacle to vessels of deep draught.

The northern extremity of the mouth is Cape Disappointment, called also Cape Hancock; the southern, a sand reef named Point Adams. Before the improvements were instituted, reefs grew from both of these, considerably narrowing the waterway. From Cape Disappointment a shoal extended to the southwest, forming Peacock spit; and from Point Adams a shoal to the northwest, forming Clatsop spit. Between these, and somewhat inside of them, there was a sand island 1½ miles long and about 1000 feet wide, which, under the action of the winds and tides, continually shifted its position. The western end of the island was prolonged into a submerged bank named the Middle Sands, which lay in a southwesterly direction for about four miles, and then became parallel to, and finally overlapped, Clatsop spit. This bank divided the channel into two parts, which reunited at some distance east of the sand island.

This combination of shoals was very unfavorable to shipping; it formed dangerous currents; and vessels, even of moderate size, were prevented from crossing the bar in stormy weather. Sailing craft were often compelled to lie for weeks outside or inside the harbor. Very frequently cargoes for foreign trade had to be sent, first to San Francisco in light vessels and thence to their destination.

In 1884, a plan was adopted of building a low tide jetty from Point Adams, or near it, to a point three miles south of Cape Disappointment. The jetty was to have a slight convexity towards the north, and was to be built largely of stone; wood, mattresses or piles being used when convenient. The project had in view the securing of a depth of thirty feet in the channel at low water.

The work was prosecuted energetically, and by October, 1885, 1020 feet of brush mattresses had been constructed. They were 36 to 45 feet wide and about two feet thick. Stone ballast from a quarry twelve miles distant was used. A short spit was built

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across an old lagoon, which overflowed in rainy weather and threatened the jetty with destruction.

Noticeable changes took place in the reef in consequence of the new channel that the water was compelled to follow; Clatsop spit became higher, several acres were added to Point Adams, and the main channel of the Columbia took a more direct course to the ocean.

Up to July 1st, 1889, 7424 feet of the main jetty had been completed, also 2580 feet of secondary construction, such as trestlework to support the rails over which the stone cars ran. The total cost of the completed portion of the jetty was over $740,000, and it was estimated that it could be finished with the expenditure of $2,423,000. Supposing, then, that adequate appropriations be made by the Legislature, the improvements of the mouth of this river will cost about $3,000,000.

### The Mouth of the Coquille River.

The mouth of the Coquille river is about 18 miles north of Point Orford. It is only 12 miles south of Coos Bay, and when the contemplated improvements have been made on it, the surrounding country will possess two fine harbors within a small distance of each other.

The south side of the entrance, which is 200 feet wide, is a bold, rocky headland; the north, a low spit of sand. In the year 1879, the maximum depth in the bay, at low water, was five feet. Navigation was exceedingly dangerous. The channel by the rocks of the southern headland had a very tortuous course. The bed of this was not fixed; but often, in one year, shifted several hundred feet. The northwest winds of summer prolonged the north spit, and the scouring action of the ebb was so much weakened in consequence that the growth of these sands was favored and the channel forced to the south. In winter, however, during the southwest gales, this action ceased, and the sand spit became much diminished in size, and the channel took once more a northerly direction.

The plan of improvement suggested comprises two parallel, high tide, stone jetties, 800 feet apart, and running from the north and south head respectively.

In 1888, after 1000 feet of a temporary north jetty had been constructed, a channel was cut through the spit and the old bed filled with sand. The spit continued to grow, but in a direction parallel to the jetty.

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# ABSTRACTS.

## Analytical Chemistry, By E. Waller, Ph.D.

*Crucibles and other apparatus.* Warren (*Chem. News*, lxiv., 146). A good substitute for a platinum crucible may be made by taking a bit of platinum foil and folding it twice as a piece of filter paper for filtering.

Gold or silver crucibles may be made by coating the outside of a porcelain crucible of convenient size, with collodion; after drying applying a solution of either gold chloride or silver nitrate. Then suspending the crucible while moist over a strong solution of $SO_3$, and finally electroplating upon the metallic surface so formed (gold or silver as the case may be) until a crucible of sufficient thickness has been formed. On drying and igniting, the porcelain core may be readily detached.

To coat flasks with metallic copper, a film upon which the metal may be electrolytically deposited, may be prepared by causing the flame of burning $SbH_3$ to impinge upon the cold surface of the flask.

*Quantitative Analysis.* Baumann (*Zts. f. Angew. Chem.*, 1891, pp. 135, 203 and 328) proposes a method depending on the reaction between $H_2O_2$ and chromates in presence of $H_2SO_4$ applicable in various cases. A flask of the general form of Wagner's azotometer is used which permits the admixture of the $H_2O_2$ with the solution after charging, and the measurement of the gas evolved. If the solution is not too concentrated it was found that one mol. $CrO_3$ evolves 4 atoms of oxygen, and 1 mol. $K_2Cr_2O_7$ evolves 8 atoms under these conditions, or 1 c.c. O at 0° and 760 min. = 2.246 mgs. $CrO_3$. $HNO_3$ except in small proportion should be absent. $CrO_3$ is estimated by converting to chromate by $H_2O_2$ in an alkaline solution, boiling to destroy the excess, and then testing in the apparatus. 1 c.c. O = 1.71 mgs. $Cr_2O_3$.

$SO_3$ may be determined by adding to the solution a known amount of $BaCrO_4$ dissolved in HCl; after shaking, the $BaSO_4$ and excess of $BaCrO_4$ are precipitated by neutralization with ammonia, and in the solution the $CrO_3$ is determined in the apparatus 1 c.c. O = 1.787636 mgms. $SO_3$.

Pb, Bi and Ba are determined by treating their precipitated chromates in the apparatus with dilute $H_2SO_4$.

1 c.c. O = 4.9776 mgs. PbO or = 5.192 mgs. $Bi_2O_3$ or = 3.42 mgs. BaO. Iodine may be estimated by using an alkaline solution of $H_2O_2$ the reaction being

$$I_2 + 2\,KOH + H_2O_2 = O_2 + 2KI + 2H_2O.$$

1 c.c. = 11.33 mgs. I. This reaction is applicable to iodometric processes. By the use of $KIO_3$ in conjunction with KI an acidimetric estimation may be rapidly effected, since the acid sets free HI which reacts with the $HIO_3$ affording free I which can be estimated in the manner sketched.

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*Separation of Baryta from Lime.* Fresenius (*Fres. Zts. Anal. Chem.*, xxx., 452) gives a continuation of his paper on this subject. If but little more $H_2SO_4$ than will suffice to form $BaSO_4$ is added, some Ba escapes precipitation, but some $CaSO_4$ goes with the precipitate giving high results; with six times as much $H_2SO_4$ as this, all Ba was precipitated but some $CaSO_4$ also came down. Too large an excess of HCl. dissolves some $BaSO_4$, but this effect is diminished by an excess of $H_2SO_4$ and with these conditions coupled with considerable dilution fairly good results were obtained. Diehl's method of separation by dissolving $CaSO_4$ out with sodium hyposulphite, did not effect a separation except in cases when the sulphates were separately precipitated and then mixed.

*Separation of Baryta from Lime.* Fresenius (*Zts. Anal. Chem.*, xxx., 595) sums up the result of his investigation of the different methods thus:

1. Affording complete separation and satisfactory results:
   - *a.* Separation by ammonium chromate, double precipitation.
   - *b.* by hydro-fluo-silicic acid, combined method.
2. Separation not quite complete but results fairly good:
   - *a.* by ammonium chromate,—single precipitation.
   - *b.* by hydro fluo-silicic acid,—washing-out method.
3. Separation much less complete, but affording moderately fair results often apparently good, by counterbalance of errors:
   - *a.* by hydro-fluo-silicic acid as practiced up to the present time.
   - *b.* Separation of the mechanically mixed sulphates by sodium hyposulphite.
   - *c.* by sulphuric acid in a solution strongly acidified with HCl.
   - *d.* by heating the freshly precipitated sulphates with $K_2CO_3$ solution.
   - *e.* by precipitation with a mixture of $K_2SO_4$ and $K_2CO_3$ (Fleischer's.)
   - *f.* by precipitation with $(NH_4)_2SO_4$ and $(NH_4)_2C_2O_4$ and titration of the $CaC_2O_4$ (Sidersky.)
4. Methods which must be designated as hardly or not at all usable:
   - *a.* by precipitation with $H_2SO_4$ from solutions containing but little HCl.
   - *b.* by treating the sulphates, precipitated together, with sodium hypo-sulphite.
   - *c.* by treating the precipitated sulphates with $(NH_4)_2CO_3$.
   - *d.* by precipitation and digestion with a concentrated solution of $(NH_4)_2SO_4$.

*Iron and Alumina in Phosphates.* Vogel (*Chem. Zeits.*, xv., 495). After precipitating the lime as sulphate by Glaser's method (vid. QUARTERLY xi. 273, xii. 262 and 338) the filtrate is precipitated by excess of ammonia which is *not* expelled by boiling. The precipitate of iron and alumina phosphates, containing also possibly some MgO, is filtered, and *without washing* 30 c.c. molybdate solution is poured upon the filter, the solution being first caught in the beaker in which the precipitation was made, and then poured back once through the filter; wash with diluted molybdate solution. The filtrate then contains $Fe_2O_3$, $Al_2O_3$ MgO and $MoO_3$. After neutralizing with ammonia, and boiling to render $Al_2(OH)_6$ insoluble, 10 c.c. of strong ammonia is added, which dissolves any MgO or $MoO_3$ that may have clung to the precipitate.

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*Separation of Ferric Oxide from Alumina.* Beilstein and Luther (*Chem. Centr.* 1891, i. 809). The nitric acid solution is evaporated to dryness and heated on the water bath until it has no more odor of acid. After dissolving in a little water, and boiling ten minutes 2 to 3 c.c. of a 10 per cent solution of $(NH_4)_2SO_4$ is added. After settling the basic ferric nitrate is filtered off. The alumina forms a basic nitrate under these conditions which is soluble.

*Separating Iron, Aluminum and Chromium.* Marchal and Wiernik (*Zts. Angew. Chem.*, 1891, 511). The solution is neutralized as exactly as possible by addition of $Na_2CO_3$. Then freshly precipitated $MnO_2$ (obtained by precipitating $K_2Mn_2O_8$ with $MnSO_4$, filtering and washing) is added, and the solution is boiled. Test a drop of the solution with ferro-cyanide. If no Fe remains in the solution all Cr has been oxydized. Filter off $Fe_2(OH)_6$ + Mn $O_x xH_2O$ and in the filtrate precipitate $Al_2(OH)_6$ by ammonia. The precipitate also carries Mn with it, from which the Al may be separated by the basic acetate method.

*Analysis of Sodium Aluminate.* Lunge (*Fres. Zts. Anal. Chem.*, xxx., 471). To solution of a weighed portion of the sample, add phenolphthalein and titrate hot. The result shows $Na_2O$, combined with $Al_2O_3$; then add one drop of methyl orange, and titrate at 30 to 37° C. The last gives the measure of the $Al_2O_3$ (1c.c. decinormal HCl = 0.0017 $Al_2O_3$). Insoluble matters are determinable by filtering the original solution before titration. If much silicate is present, the titration results are inaccurate.

*Aluminum in Iron and Steel.* Drown and McKenna (*Am. Inst. Min. Eng.*, Cleveland meeting, June, 1891) have experimented with a method consisting in electrolytically separating the Fe, using a mercury cathode, and in the filtrate precipitating the Al as phosphate. In attempting to determine the iron separated it was found that the mercury vaporized perceptibly by heating when it was attempted to dry it. Error from this source was found to be preventable by using a blank beaker of mercury in the circuit and drying for only two minutes at 100° before weighing. A current of two ampères was found to be best, with a nearly neutral solution of small bulk, and at least 50 times as much Hg as there was Fe present. Under these conditions 10 grammes of Fe precipitated in 10 to 15 hours. Mn if present, partly oxidizes and deposits on the anode, and partly reduces and alloys with the Hg. Phosphoric acid seemed to have no influence on this method of separating Fe. No Al is precipitated. The method adopted consisted in dissolving 5 to 10 grms. of the manufactured iron in $H_2SO_4$ evaporating to fumes dilution, filtering, etc. After nearly neutralizing with ammonia, and adding about 100 times as much Hg as the weight of the iron taken, dilute the solution to 300 to 500 c.c., and electrolyze over night. When the solution gives no reaction for Fe., remove the solution, and wash without breaking the circuit. To the solution and washings add excess $Na_2HPO_4$ and about 10 grms. of acetate, nearly neutralize with ammonia and boil for at least 40 minutes, filter, etc. Avoid excessive washing. The precipitate after ignition should be white. Its composition under these conditions seems to be 7 $Al_2O_3$, 6 $P_2O_5$ contain-

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ing 24.14 per cent. of Al. If the precipitate is colored with iron, it should be rendered soluble by fusion with $KHSO_4$ and electrolyzing again etc.

*Manganese in Slags and Ores.* Norris (*Jour. Anal. Chem.*, v., 430). *In slags.* Treat 1 grm. with 50 $HNO_3$ (Gr. 1.43) boil and add 3 or 4 c. c. of HFl. Boil to remove HFl. Then precipitate with $KClO_3$ and treat as in the Ford-Williams method. *In ores.* 1 or 0.5 grm. according to richness is treated with 50 c.c. $HNO_3$ as above. Bring to a boil, and add a few pieces of tartaric acid. When the solution clears, add a little HFl and boil. Then precipitate with $KClO_3$ and manage as before. A determination can thus be effected in 45 minutes.

*Separation of Manganese and Zinc.* Jannasch and McGregory (*Jour. f. Prakt. Chem., Chem. News* lxiv., 182) find that $H_2O_2$ separates $MnO_2$ completely, provided a large excess of $NH_4Cl$ and ammonia are present. To a solution containing 0.5 grms. each of these metals, was added 100 c.c. of a 15 to 20 per cent solution, of $NH_4Cl$., and a corresponding bulk of strong ammonia. On adding 50 to 60 c.c. pure $H_2O_2$ solution, and heating for about 15 minutes on the water bath, $MnO_2$ free from Zn was completely precipitated. In the filtrate the Zn may be separated as sulphide or it may be evaporated to dryness, and the $NH_4Cl$ volatilized off by cautious heating over a bed of asbestos. Direct heating by the flame will cause the loss of some Zn.

*Volatility of Nickel, etc.* Schutzenberger (*C. Rend.* cxiii., No. 4) finds that when dry $NiCl_2$ is heated in a current of hydrogen, some Ni is volatilized. The same phenomenon was observed with the Fe and Zn salts.

*Delicate Reaction of Copper.* Thoms (*Phar. Central H.*) finds that distilled water containing minute traces of Cu, such that ammonia or ferrocyanide fail to show, assumes a yellow tinge with KI, from freeing of I according to the well-known reaction ($Cu_2I_2 + I_2$).

*Determination of Chrome Yellow.* Lashand and Lepierre (*Bull. Soc. Chim.* vi. 235). Lead chromate in contact with dilute KOH reacts thus: $2PbCrO_4 + 2KOH = PbO.PbCrO_4 + K_2CrO_4 + H_2O$. If an known amount of alkali is used, the insoluble basic chromate may be filtered off, and the alkali remaining determined by use of standard sulphuric acid using phenol phthaleine as indicator.

The authors treat 2 grms. of the sample with 20 c.c. of double normal KOH, in a flask fitted with a ground stopper. After shaking until the color of the neutral chromate has been completely changed to that of the basic salt, water is added, and after filtering or allowing the precipitate to settle, an aliquot portion of the clear liquid is titrated. A test may be made in ten minutes.

*Determining Antimony.* Thiele (*Liebig's Ann.* cclxiii., 361) has investigated the methods depending on separation in the metallic state, by means of iron, dissolving out the Fe by HCl washing and weighing. Some Sb (1 or 2 per cent.) always went into the washings. As to methods for determination as $Sb_2S_5$ the results were always too low, the precipitate containing $Sb_2S_3$ or else having been decomposed by the $CS_2$ used.

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*Separation of Antimony and Arsenic.* Gooch and Danner (*Chem. News*, lxiv., 203). The use of HI as a reducer instead of a ferrous salt in Fischer's method (distilling off $AsCl_3$) is proposed. The process is conducted in a flask arranged with a glass stopper arranged in such a way that HCl gas may be passed in, and the distillation at the same time carried on, the vapors coming only in contact with glass. To the solution containing not over 0.5 grms. of either element is added a little over 0.5 grms. KI, and enough concentrated HCl to make the bulk up to 100 c.c. HCl gas is then passed in to saturation, the passage of the gas being continued throughout the distillation. After about 50 c.c. or over has been distilled off, the arsenic is in the distillate, while the antimony remains in the flask. This is cooled quickly, and treated first with an excess of $SO_2$, then with iodine to exact oxidation of the surplus $SO_2$. Then 1 grm. tartaric acid is added for every 0.2 gm. $Sb_2O_3$ present, and the liquid is neutralized with soda, being completed with $NaHCO_3$. After adding 10 c.c. saturated $NaHCO_3$ solution for every 0.1 grm. $Sb_2O_3$ present, the solution is titrated with $\frac{1}{10}$I solution which has been standardized against tartar emetic. Results are obtained in about 1½ hours.

*Arsenic Antimony and Tin in Gray Copper Ore, etc.* Hampe (*Chem. Ztg.*, No 26). Use 10 grms $H_2C_4H_4O_6$ and 30 c.c. $HNO_3$ per gramme of ore and allow the mixture to stand for some hours warm. Any undissolved residue is treated with $K_2S$. Heat to 60° C and pass $H_2S$. Treat the precipitate with $K_2S$, precipitate that solution with $H_2SO_4$, dissolve the $(NH_4)_2S$, evaporate to dryness,—oxidide with HCl and $KClO_3$, then add $H_2C_4H_4O_6$ and precipitate As by magnesium mixture. The precipitate should be purified by re-solution in HCl, and re-precipitation with ammonia. In the filtrate separate Sn and Sb by Rose's method.

*Determination of Molybdic and Tungstic Acids.* Smith and Bradbury (*J. Anal. Chem.*, v. 481). It was found that these acids could be precipitated as barium salts. For molybdic acid after adding $BaCl_2$ and boiling some time; the solution needed to be cooled before filtering, and washed with cold water. The tungstate did not require cooling. Both Ba salts dissolve to some extent in $NH_4NO_3$ solution. The precipitates detached readily from the paper, but had to be dried at a temperature below red heat. Ca salts were serviceable for the determination of $MoO_3$ but not for $WO_3$. For the former, after adding $CaCl_2$ to the boiling solution, and boiling until the precipitate became granular, the solution was cooled, and one third its volume of strong alcohol added. After standing over night, this was filtered and washed with diluted alcohol (1 : 3). The precipitate required heating strongly for 15 minutes before weighing.

Precipitation as the Pb compounds was found to be satisfactory. In the case of $WO_3$ the use of $NH_4NO_3$ in the solution and wash water was practically indispensable. Determination as the Ca salts was found also to be practicable. The Ag and Co salts were not of service for quantitative estimations.

*Electrolytic Separation of Iron.* Smith and Muhr (*J. Anal. Chem.*, v., 488). Metallic iron was readily deposited from solutions containing

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tartaric acid and an excess of ammonia. The deposit, however, always contained some carbon in varying amounts. The separation from Al. can be thus effected; Ni, Co, Zn, Cu or Cd can be precipitated in the same manner, and none of these metals carry carbon with them.

*Electrolytic Determination of Metals as Amalgams.* Vortmann (*Berichte,* xxiv., 2749). The idea of using mercury in connection with the negative pole has been proposed by Gibbs and Luckow. The author proposes to precipitate mercury on a platinum dish from a solution containing a known amount of $HgCl_2$ (or a solution of HgO) simultaneously with the metal to be determined. The strength of current used should be about 6 to 8 c.c. of gas per minute at the start, until the metals begin to separate, when it is reduced to 2 or 3 c.c. and afterward gradually increased up to 6 or 8 c.c. The precipitated metal if washed successively with water, alcohol and ether, and then dried by the warmth of the hand aided by a gentle blast of air, can be kept for some days without loss. Experiments were first made on the separation of Hg from: 1. The double ammonium oxalate. 2. From ammoniacal solution containing tartaric acid. 3. From $Na_2S$ solution containing NaOH and 4. From KI solution. In the first there is a tendency to a separation of $Hg_2Cl_2$ which prolongs the time necessary for reduction, especially if the solution is warm.

*Zinc* can be separated from the double ammonium oxalate solution using an excess (3 to 5 gms) $(NH_4)_2C_2O_4$. Not too large an excess of Hg must be used (at most 2 to 3 parts Hg to 1 part Zn) or a partially spongy precipitate results, which is difficult to wash and dry.

*Zinc* can also be determined in the ammoniacal tartrate solution. In this case at least three times as much Hg as Zn must be used, since otherwise the amalgam exfoliates. An excess of Hg does no harm. In this case the amalgam attacks the platinum dish.

*Cadmium* can be separated in a similar manner to zinc. The oxalate solution is only to be recommended when the amount of Cd is small. 0.2 to 0.3 gm. as the double ammonium oxalate is not very soluble. If over 0.3 gm. Cd is present, add 3 gms. $H_2C_4H_4O_6$, at least four times as much Hg as Cd, render strongly alkaline with ammonia and electrolyze.

*Lead* can also be determined. The tendency to the formation of $PbO_2$ on the positive electrode was prevented by the use of nitrite. The Pb salt and $HgCl_2$ were dissolved in water, 3 to 5 gms. $NaC_2H_3O_2$ added, then a few drops of concentrated solution of $KNO_2$, then $HC_2H_3O_2$ to dissolve the white precipitate which formed, and the solution subjected to electrolysis, a few drops of the $KNO_2$ solution being added whenever brown $PbO_2$ appeared on the positive electrode. The deposited amalgam needs to be rapidly washed and dried, since it oxidizes quickly when moist. Pb can also be separated from a solution slightly acid with $HNO_3$, if $KNO_2$ solution is added from time to time, but the operation is longer than with the acetic solution. In an alkaline solution no formation of $PbO_2$ occurs. Dissolve the Pb salt and $HgCl_2$ in water, add a few grms. $H_2C_4H_4O_6$, then an excess of NaOH, and KI

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until the precipitate dissolves; dilute as much as possible, and electrolyze. This mode of procedure is better for purposes of separation than of determination as the amalgam cannot be safely washed with alcohol, and if washed with hot water and dried, the results are always high.

The ammoniacal tartrate solution is serviceable for the separation of Pb from Sn, Sb and As.

*Bismuth.* The double ammonium oxalate is too slightly soluble in water to be of service. In acid solutions the tendency to the formation of basic salts may be checked by addition of KI or of alcohol rather than of acid. in ammoniacal solutions the proportion of Hg must be larger than with acid or neutral solutions (KI sol'n.).

*Antimony.* The metal must be in the pentad form. The Sb salt together with the necessary amount of $HgCl_2$ was dissolved in warm water with addition of excess of strong Br. water. Then NaOH with $Na_2S$ solution was added until a clear solution resulted, and after dilution so far as possible, the solution was electrolyzed. At the end of the operation the positive electrode had a thin coating of sulphur, which during the progress of the deposition was black from HgS. When a few drops of the solution gave only a white milkiness with dilute $H_2SO_4$ the operation was finished. Tin is not deposited under these conditions. Experiments on the separation of arsenic in an amalgam have thus far been unsuccessful.

*Electrolytic Separation of Mercury from Copper.* Smith and McCauley (*J. Anal. Chem.*, v., 489). The separation in a cyanide solution requires a careful adjustment of the current. The larger the proportion of Cu present, the weaker the current must be. The presence of Zn, Ni, etc., caused no interference.

*Separating Halogens.* Forbes (*Chem. News*, lxiv., 112.) By slightly heating a mixture of alkaline chloride, bromide and iodide, with $MnO_2$ and acetic acid, free I is obtained; after driving this off the addition of a little $HNO_3$ set free Br. After removing this and *cooling* the tube, $H_2SO_4$ is added and heat applied when Cl is set free.

*Phosphorus in Irons. Centrifugal process.* Reinhardt (*Chem. Zeits.*, xv., 410) describes the method which is used in many German steel works. It depends on the measurement of the bulk of the phosphomolybdate precipitate obtained, after compacting it by means of centrifugal action in a graduated tube terminating above in a pear-shaped bulb. The value of each division of the tube is determined by comparison of results with gravimetric estimations. In making the tests an absolutely uniform method of procedure is indispensable. 2 gms. of the iron or less if the P is 1 per cent. or over, is sufficient for the test. The carbon which might add to the bulk is removed by addition of permanganate in excess and then removing the excess by use of $K_2C_2O_4$ solution added drop by drop. Silica has to be filtered off if much in amount. For details of the method the original paper should be consulted.

*Sulphur in Iron and Steel.* Hattensaur (*Chem. Zeit.* xv., 521) gives

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a series of comparative analyses of Siemens-Martin metal by the (HCl) evolution method, and by dissolving in sodium copper chloride. The results show a close agreement, although one sample contained 0.16 per cent. Cu.

*Estimation of Boric Acid.* Hehnr (*Analyst*, xvi., 141) gives the results of experiments on the fixing of boric acid with different reagents, it being already satisfactorily established that the acid can be distilled off from its combinations by treatment with sulphuric acid and methyl alcohol. Magnesia fixes it only with difficulty. Lime fixes it readily, but it is difficult to ignite the product to constant weight. Fixing with ammonia or with $Na_2CO_3$ was found to give unsatisfactory results. $Na_2HPO_4$ gave fairly good results, though it was necessary to ignite with great care to prevent spurting. The indications seemed to be that 1 mol. $Na_2HPO_4$ was capable of fixing 2 mol. $H_3BO_3$.

Fixing by means of borax as recommended by Stolba, was found to be possible, but extreme care to avoid loss by crepitation or ignition was necessary.

*Boric Acid in Waters.* Parmentier (*C. Rend.*, cxiii. No 1). The waters were first concentrated, then acidified with HCl and evaporated to dryness at a low temperature. On taking up with dilute HCl, and adding $NH_4NO_3$ containing a little free ammonia, the boric acid was retained in solution, phosphoric acid, alumina etc., being precipitated. The clear filtrate was divided exactly in halves and then acidulated with HCl or $H_2SO_4$. These were titrated with standard soda, using helianthine as indicator, in the one case, and DeLuynes litmus solution in the other. The difference in the results gave the measure of the boric acid present. With the litmus, the neutral point indicates the formation of the bi-borate.

*Nitrates by the Carbazol test.* Mason (*Chem. News*, lxiv. p. 97) has experimented with this method (vid. QUARTERLY x. 379), and finds that the temperature of the solutions has a marked effect on the development of the color. The method is found to be somewhat disappointing.

*Detection of Nitrates and Chlorates.* Forbes (*Chem. News.*, lxiv, 165). When both are present or suspected, mix the solution with $H_2SO_4$, insert a piece of Cu foil and heat the test-tube in a boiling bath of brine. The chlorate decomposes first, giving the characteristic Cl fumes. At a higher temperature the brown fumes from decomposition of the nitrate appear.

If chlorates are absent, add HCl to some of the solution to be tested, drop in a piece of Pb foil, and heat. If nitrates present the Pb dissolves and white $PbCl_2$ separates on cooling. I or Br vapors if those elements are present, may mask the nitrous fumes, but if $HNO_3$ is absent no $PbCl_2$ is formed.

*Examination of Gun Cotton, etc.*, Essner (*Abstract in Bull. Soc. Chim.* vi., 376). The nitrogen may be determined by dissolving the sample in concentrated $H_2SO_4$, and making the test in a Lunge nitrometer, measuring the NO evolved. For alkaline nitrates and other salts, wash

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10 grms. of the sample repeatedly with hot water until the washings show no residue. Evaporate and weigh the material washed out. Boiling with water or too prolonged a contact with hot water tends to cause the formation of nitrous ethers and consequent loss.

For moisture dry at a temperature not exceeding 45° to 50° C.

A portion of the residue from washing should be heated in a small flask or tube to 65° C, and there should be suspended over it a paper saturated with KI and starch solution containing 10 per cent of glycerine. The rate at which decomposition ensues (shown by the action of the nitrous fumes in setting free I), gives a basis for judging as to the degree of nitration of the cotton mono- di- tri- etc. For ash mix with paraffine and ignite.

Another portion of the residue from washing is treated with a mixture of one part absolute alcohol with two parts absolute ether. Dry and determine by loss, the amount of mono- di- tri- tetra- and penta-nitro cellulose. Hexanitro cellulose and unnitrated cellulose remains. Determine the latter by use of Schweitzer's reagent.

*Determination of Ferro-cyanides* in Prussiate melt, and spent Lanning mixture. Zaloziecki. (*Fres. Zts. Anal Chem.*, xxx., 484). The method depends upon the precipitation of double ferro-cyanide of zinc and alkali from a neutral solution by introduction of zinc carbonate to the hot solution and passing $CO_2$. In the filtrate the amount of alkaline carbonate resulting from the reaction, may be titrated alkalimetrically. The reaction is: $3\,K_4FeCy_6 + 4\,ZnCO_3 = 2\,Zn_2\,FeCy_6$. $K_4\,FeCy_6 + 4\,K_2\,CO_3$. The mode of preparing the solution for treatment with the zinc carbonate, etc., in each case is described.

*Total Solids in Water.* Hazen (*J. Anal. Chem.*, v., 440) revives the method of determining solids on evaporation, by adding a measured amount of $Na_2CO_3$ before evaporating. A series of results which are quoted seem to indicate that results by this method are more accurate than when no addition is made.

## METALLURGY, BY JOSEPH STRUTHERS.

REFRACTORY MATERIALS—*American Manufacturer and Iron World*, Oct. 2, 1891.—Magnesite occurs in Napa Co., California, where it is mined and calcined for the market. The magnesite is hard, white and flinty, giving 43 per cent. carbonic acid, 50 per cent. magnesia, 7 per cent. silica, lime, iron and moisture. It occurs in ledges from two to six feet in thickness, apparently running deep and extending upward of half a mile as marked by heavy surface crossings. The rock is blasted out as in a quarry, broken to suitable size and calcined in a continuous kiln having a capacity of 5 tons per 24 hours. This calcined material is used at the Williamette Pulp and Paper Co. in the treatment of sulphite fibre in the manufacture of wood pulp. It is also used metallurgically in San Francisco.

IRON ORES—*Census Bulletin No. 113* contains the report of Mr. John Birkinbine on the iron-ore industry of the United States.

The production of 1889, as compared to 1879, is as follows:

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| | 1889. | 1879. |
|---|---|---|
| Iron-ore produced (long tons), | 14,518,041 | 7,120,362 |
| Valued at, | $33,351,978 | $23,156,957 |
| Average per ton, | $2.30 | $3.25 |

The four leading States and their productions being:

| | Long Tons. |
|---|---|
| Michigan, | 5,856,169 |
| Alabama, | 1,570,319 |
| Pennsylvania, | 1,560,234 |
| New York, | 1,247,537 |
| Total, | 10,234,259 |

| | |
|---|---|
| Number of employees engaged in mining iron ore, | 37,707 |
| Wages received by them, | $13,880,108 |

| Capital invested. | 1889. | 1880. |
|---|---|---|
| Land, | $78,474,881 | $48,274,149 |
| Buildings, etc., | 7,673,520 | 8,657,375 |
| Tools, etc., | 8,045,645 | |
| Stock on hand, | 15,572,253 | 4,850,763 |
| | $109,766,199 | $61,782,287 |

| | Tons. |
|---|---|
| Stock on hand beginning of census year, | 1,966,284 |
| " " " end " " " | 2,256,973 |

Total cost of mining iron-ore per long ton for the States producing largest amounts:

| | |
|---|---|
| Michigan, | $2 07 |
| Alabama, | 82 |
| Pennsylvania, | 1 10 |
| New York, | 1 64 |
| Total average for U. S., | $1 71 |

Comparison of outputs:

| | 1880. |
|---|---|
| Largest output of any one mine (tons), | 250,000 |
| Next largest output, | 200,000 |
| Eight mines produced each, | 100,000 |

| | 1890. |
|---|---|
| Largest output, tons, | 809,000 |
| Next largest output, | 760,000 |
| Two mines produced between, | 500,000 and 600,000 |
| Two mines produced between, | 300,000 and 400,000 |
| Eleven mines produced between, | 200,000 and 300,000 |
| Seventeen mines produced between, | 100,000 and 200,000 |
| Thirty-one mines produced between, | 50,000 and 100,000 |

This number (65) being the mines compared in following table. The largest producers are in Michigan.

Comparison of outputs of individual mines of 50,000 tons production each per year:



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| | 1889. | 1879. |
|---|---|---|
| Number of mines, | 65 | 19 |
| Ore, Red Hematite, | 46 | 10 |
| Magnetite, | 9 | 9 |
| Brown Hematite, | 8 | ... |
| Carbonate ore, | 2 | ... |
| Total product of mines, | 10,391,490 | 2,197,180 |
| Percentage of total product, | 71.58 | 30.86 |
| Value of products, | $24,340.611 | $8,222,640 |
| Percentage of total value, | 72.68 | 35.51 |

Estimated average expenditure in labor and wages per long ton of ore for mining:

| | Character of mine ore. | Average cost per ton. |
|---|---|---|
| Alabama, Georgia, North Carolina, | Large open workings, Soft ore and systematic working, | 69-71c. |
| Pennsylvania, | ½ from Cornwell ore hills —accessible—soft ore, | 75c. |
| Lake Superior, | Hard ore, | $1.19 |
| Colorado, Idaho, Montana, | Smaller output, High wage rate, | $2.21-2.48 |

| | Remarks. | Average cost. |
|---|---|---|
| All States and Territories | year 1889, | $1 71. |
| | " 1880. | $2 21. |

Difference of average cost accounted for chiefly by labor-saving devices and improved facilities for washing ore.

Importation of iron ore into United States, 1889:

| From | Tons. |
|---|---|
| Spain, | 298,568 |
| Cuba, | 243,255 |
| French Africa, | 97,583 |
| Italy, | 87,410 |
| England, | 54.496 |
| Other sources, | 72.261 |
| Total, | 853,573 |

Value, $1,852,392.

This report also discusses the commercial value of iron ore, the handling and transportation, and gives descriptions of docks specially constructed for handling the Lake Superior ores.

AMERICAN BLAST-FURNACES.—*The American Manufacturer and Iron World* for October 16, 1891, gives an interesting tabulation of the condition of blast-furnaces in the United States, stating the number of furnaces in and out of blast and their weekly capacities.

The furnaces are classified according to the fuel used, viz: Charcoal, anthracite and bituminous coal or coke, and are grouped under States and districts. Comparative monthly standing of the furnaces and their capacities is given from January 1, 1889, to October 1, 1891.

The condition of the furnaces October 1, 1891, was as follows:

| Fuel. | In Blast. No. | In Blast. Weekly Capacity. | Out of Blast. No. | Out of Blast. Weekly Capacity. |
|---|---|---|---|---|
| Charcoal, | 59 | 12,710 | 66 | 4,922 |
| Anthracite, | 87 | 34,594 | 70 | 23,435 |
| Bituminous coal or coke, | 159 | 134,514 | 92 | 52,812 |
| | 305 | 180,818 | 228 | 86,169 |

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ENGLISH BLAST-FURNACES.—*Iron* for October 16, 1891, gives the following list of furnaces in blast in England, Wales and Scotland, compiled from Ryland's *Iron Trade Circular*:

| | Furnaces in blast Sept. 30, 1891. |
|---|---|
| England, | 185 |
| " (Cleveland district), | 90 |
| Wales, | 29 |
| Scotland, | 75 |
| | 369 (sic.) |

PIG IRON, THE ELIMINATION OF SULPHUR FROM.—*The London Mining Journal* for October 1, 1891, gives the following abstract article on "The Elimination of Sulphur from Pig Iron," a paper read before the Iron and Steel Institute, England, October 7, 1891, by the Secretary, on behalf of Herr J. Massenez, of Hörde, Germany:

"The author, in the course of his paper, said that if in the acid and the basic Bessemer process, the molten pig-iron was taken direct to the converter from the blast-furnace, there was the disadvantage that the running of the individual blast-furnaces could hardly ever be kept so uniform as it was desirable should be the case in order to secure regularity in the converter charges. In the manufacture of Bessemer steel the variable proportions of silicon and of carbon here came chiefly under consideration, whilst in the basic process it was chiefly the varying proportions of silicon and of sulphur, and in cases where either ores with variable percentages of phosphorus or puddle slags were to be treated, the varying proportion of phosphorus had also to be considered. This disadvantage of the irregular composition of the individual blast furnace charges was obviated in a simple and effective manner by W. R. Jones' mixing process. In this, as much pig-iron from the various blast-furnaces of a works as was sufficient for a large number of Bessemer charges, say from 7 to 12 charges, or in other words from 70 to 120 tons of pig-iron, was placed in a mixing-vessel. Only a portion of pig-iron placed in the mixer was taken for further treatment for steel, whilst new supplies of pig-iron were brought from the blast-furnace. In this way homogeneity sufficient for practical purposes was obtained. In the treatment of phosphoric pig-iron which was employed in the production of basic steel, it was, however, not sufficient merely to conduct the molten pig-iron in large quantities to the converter in a mixed condition, but the problem here was to render the proportion of sulphur also independent of the blast-furnace process to such an extent that the proportion of sulphur in the finished steel was so low that the quality of the steel was in no way influenced by it. The question of desulphurization had, especially of late years, become of the utmost importance, at any rate for the iron industry of the Continent, and in order to effect satisfactory desulphurization, attention had been bestowed on the fact that iron sulphide was converted by manganese into manganese sulphide and iron. If sulphuretted pig-iron, poor in manganese, was added in a fluid condition to manganiferous molten pig-iron, poor in sulphur, the metal was desulphurized and a manganese-sulphide slag was formed. It might be urged that it did not seem necessary to effect the desulphurization by

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means of the reaction of the manganese and iron sulphide outside of the blast-furnace, as it was possible, by suitably directing the blast-furnace process, by the employment of manganiferous ores of highly basic slag, so to desulphurize the iron in the blast-furnace itself that it would be unnecessary further to lower the percentage of sulphur. Every blast-furnace manager, however, would have observed that, even with every precaution in the blast-furnace practice, pig-iron would often be obtained with so high a percentage of sulphur as to render it useless for the Bessemer acid or basic processes. If the desulphurization in the blast-furnace was carried sufficiently far, it was always necessary to work the furnace hot, and thus to obtain hotter iron than was desirable for further treatment in the converter. On the other hand, the method of further desulphurization outside the blast-furnace, described in this paper, presented the double advantage that part of the blast-furnace could be kept cooler, and thus lime and coke were saved, and that there was a certainty that no red-short charges were obtained in the treatment in the converter, while the pig-iron passed to the converter at a suitable temperature. A further advantage presented by the direct process described in this paper, was that the Bessemer works are independent of the time at which the individual blast-furnaces were tapped, as the pig iron required for the Bessemer process could be taken at any moment from the desulphurizing plant. In Hœrde, where the mixing and desulphurizing process had for a considerable time been regularly in use, it had been found that all the chief difficulties formerly encountered in the method of taking the fluid pig-iron direct from the various blast-furnaces to the converter had been obviated. A number of results obtained at the Hœrde Works were given by the author.

"Sir Lowthian Bell said they had one of the mixers at Barrow, and it followed, apparently without any cause, that there were variations in the decomposition of the pig-iron obtained. He was bound to say that since they had applied the mixer, of course they had what was really called an average. That was, the mixer contained about 100 tons of ore, 10 running in at one end and 10 out at the other, so that practically they had an average of very likely 10 furnaces or more in one converter. Since they had taken to use that instrument the defectives had fallen down to something like one half of what they were before. The expense was little or nothing. With regard to the disappearance of silicon of course a certain amount did disappear in the converter. But he thought that was easily accounted for. Of course the value of this invention was very great and especially so in Germany, where, as he had that week been informed, nine-tenths of all the steel now made in that country, was made by the Massenez process. He entirely agreed with the principles laid down by Mr. Massenez."

CONTINUOUS SHEETS OF MALLEABLE IRON AND STEEL.—In the *Mining Journal of London* for October 10, 1891, is presented an abstract from the paper of Sir Henry Bessemer on "The manufacture of continuous sheets of malleable iron and steel direct from fluid metal." The author gives the history of the development of this important process and a description of the improved rolls, which is essentially as follows: The rolls may be 3 or 4 feet in diameter, each flanged on one end forming a trough with closed ends for the fluid metal, and are hollow and water

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cooled. The brass support of one roll being fixed and of the other movable in a suitable slide, the latter support being pressed by an hydraulic ram which is in free communication with an accumulator, so that at any time should the feed of metal be in excess the second roll will move and prevent any undue stress in the machinery. A regular and quiet supply is secured by means of a small iron box lined with plumbago or fireclay along the bottom, having ten or twenty small holes about a quarter of an inch in diameter. This reservoir is heated before use by means of a specially constructed stove. The ladle, mounted on wheels, is conveyed over the rolls by means of a railway, and tapped into the reservoir. The quantity of metal flowing therefrom to the rolls varies but slightly, depending on the head of metal in the reservoir; this can be easily regulated to advantage. The streams of molten metal do not fall direct on to the rolls, but into a small pool formed between the thin films solidifying against the cold surface of the rolls, the metal at all times being free from floating slag.

The speed of the rolls also affords a means of regulating the quantity of metal retained between them, and as a pair of four-foot rolls only require to make about four revolutions per minute, a quick running engine can easily be provided with differential speed gearing so as to instantly alter the speed of the rolls to the very small extent ever required during the rolling process. The thin sheet of metal as it emerges from the underside of the rolls is received between curved guide-plates, to one of which a cutting blade is bolted. Beneath the other guide plate a similar cutting blade is arranged to suddenly move forward by a cam and cut the thin sheet in two, the piece so cut afterwards passing between the second pair of rolls from which it again descends by gravity and passes between the third pair of rolls and is delivered to a horizontal table, or it may be allowed to slide down the inclined end of the water cistern and thus cooled.

The thickness of the plates capable of being produced depends on size of the rolls. If drums of 10 to 12 feet diameter were used it is probable that plate ¾ inch thick could be produced, or perhaps even thicker. The centre space between drums of such large diameter would represent a sort of plate ingot mould with nearly parallel sides for some 8 to 10 inches depth.

In discussing the product, Sir Henry Bessemer says: "In producing sheets of metal, the initial thickness of which does not exceed one tenth of an inch, it might at first sight appear that the finished plate with only two more rollings would not get sufficient work done upon it to develop the same degree of toughness and cohesion that would be obtained by the many rollings which the present system necessarily involves; but a little consideration will render apparent the entirely different conditions under which the formation of plates take place. Mild cast-steel is a crystalline substance and follows the inevitable law of all crystalline bodies in so far as the size of the crystals depend on the bulk of the mass and the time allowed for their formation; the longer the time allowed, and the greater the mass, the larger are the crystals obtained; their planes of cleavage are also more clearly defined and are more easily separated from each other, or, in fact, have a less amount of cohesion. A cast ingot one foot square quietly reposing in

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a soaking-pit or heating-furnace may go on crystallizing for two or three hours and develop a coarse crystalline structure, but, in rolling fluid steel in the manner proposed, we have, in place of the ten-inch ingot, a sheet one hundredth of that thickness only, and in lieu of the two or three hours allowed in the ordinary cases for the development of crystals, we have, when using a four-feet pair of rollers, making four revolutions per minute a transition from absolute fluidity to absolute solidity in just one half a second of time, in a mass of only one tenth of an inch in thickness; and if crystals are developed at any period during the half second of time occupied in this transition they must be microscopic indeed, and possess but little, if any, of the properties that are developed in large masses during hours of repose in the soaking-pit; hence it appears to me highly probable that the homogeneous fluid metal will pass at once into a perfectly homogeneous uncrystalline body, and being subjected to fluid, semi-fluid and solid pressure in rapid succession will develop the full cohesive force and toughness which the metal is susceptible of. It will be at once perceived that in this mode of disposing of a ladleful of steel in the rolls we avoid the cost and the wear and tear of casting moulds and the labor of their removal and rearrangement at each casting operation, also the need of soaking-pits or reheating furnaces with their accompanying cost of labor and fuel. There will also be no loss arising from waste end of piped ingots, etc. It will be understood that thin sheets so produced will not acquire any scale during the single minute they are exposed to the oxidizing atmosphere prior to their immersion in the water tank, and in consequence of there being no overlapping of plates in rolling there will be but little loss of metal in shearing. With reference to the speed of production let us assume the mill to be fitted with a pair of four-feet diameter rolls 18 inches wide, making four revolutions per minute and set to produce a sheet having an initial thickness of one-tenth of an inch and rolled by a third pair to one-twentieth of an inch. We should thus have a surface velocity of the first pair of rolls equal to 50 feet per minute, and making, when finished, 100 plates 18 inches by 12, one-twentieth of an inch thick and weighing 300 pounds or equal to a production of one ton of plates in seven and a half minutes. Hence it becomes a question as to which is the least costly mode of dealing with a ladleful of fluid steel—forming it into massive ingots in moulds, or making it into thin sheets in the manner proposed."

[NOTE.—In the *Engineering and Mining Journal* for October 24, 1891, page 473, are cuts illustrating rolls and reservoir.]

IRON AND STEEL—THE EFFECT OF LOW TEMPERATURE.—*Iron*, Sept. 25, 1891.—Herr F. Steiner, Professor at the German Technical High School in Prague, communicates the results of some interesting experiments which he made with the view of determining the influence exercised on iron and steel by a very low temperature. The tests conducted on strips of welded iron, ingot iron and English cast steel. Size of strips were 20 centimeters long, 3 to 5 centimeters wide, and 7 to 10 millimeters thick; duplicate strips of each class being laid to one side for comparison. The stated qualities of these strips gave:

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| METALS. | Breaking Strength. | Extension, Per cent. | Sectional Contraction, Per cent. |
|---|---|---|---|
| Welded iron..... | 3500 | 18 | 20 |
| Ingot iron..... | 3600 | 30 | 60 |
| Cast-steel ..... | 6000 | 4 | 9 |

Half of the test-pieces were experimented upon in an undamaged condition and the other half were notched with a chisel about one millimeter deep on one side at the middle. It was seen from the result that these notches materially influenced the subsequent behavior of the metals.

The pieces of iron and steel were refrigerated by means of liquid carbonic acid in a bag of non-conducting material. The liquid carbonic acid, when poured on the strips was immediately solidified into a snow-like mass by the evaporation of some of the acid, which attached itself to the test-pieces. When a strip was covered with the solid carbonic acid it was left in that condition for thirty minutes and then withdrawn and submitted to the following test: The metal piece was laid over a mould having a depression in the centre; a piece of bar iron was laid diagonally across the test-piece to receive and convey to the test-piece the very light blows of a small teel hammer.

The most important results obtained were as follows: (1). The three classes of iron after being powerfully refrigerated and then gradually allowed to regain their normal temperature showed no appreciable alteration in the bending tests. (2). Undamaged welded iron in the refrigerated state was bent to an angle of 180° without breaking; the notched piece could not be bent further; the broken surface, fibrous in the unrefrigerated condition, presented a granular appearance in the refrigerated state. (3). Soft undamaged ingot iron, and also the steel after undergoing a slight bending on receiving the third weak blow of the hammer sprang asunder with a crackling noise as of glass. The notched or damaged pieces of these two sorts burst in the same manner at the first light blow without submitting to the bending test. The broken surfaces of the refrigerated pieces showed a grained formation, in the case of steel almost coarse-grained.

These trials clearly demonstrate the prejudicial effects of a great degree of cold upon those building materials, and the following conclusions are to be drawn; namely, that ingot iron bridges should be crossed but slowly when abnormally low temperatures prevail, and that every care should be taken in building to avoid external fractures of the ingot iron constructional parts of a bridge.

COPPER SMELTING.—"The Basic Process as applied to Copper Smelting," Percy D. Gilchrist, A.R.S.M.—*Journal of the Society of Chemical Industry*, January 31, 1891.—In the case of steel manufacture, the result arrived at in substituting a basic lining for an acid was well defined, viz: the removal of phosphorus, a problem incapable of solution in acid-lined furnaces owing to the acid nature of the slags necessarily formed with such linings, but which was readily accomplished as soon as the presence of a basic lining in the furnaces allowed of a basic slag being formed and maintained. No such direct improvement, however, was

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to be looked for in the case of copper smelting as the only deleterious element occurring with any frequency in crude copper, viz., arsenic, can be very perfectly eliminated in the acid lining at present made use of. A careful study of the composition of copper roaster and refinery slags reveals the fact that, unlike steel slags from acid practice, the copper slags formed during the removal of the arsenic, are basic and not acid in character, the basicity being chiefly due to the presence of copper oxide in quantity more than sufficient to neutralize the silica, which latter in the roaster and refining furnaces, originates almost wholly from the sand or clay used to form the furnace-bath. Lime or lime and soda-ash are used very generally in the ordinary sand-lined refinery, but the quantity which can be added without detriment to the lining is not large and does not compensate for the large amount of silicious material which is dissolved away from the sides of the furnace. It was, therefore, rather in the direction of lessened oxidition and consequent increased yield that the author expected improved results by the use of basic linings and more calcareous slags in copper-smelting.

In May, 1889, a trial was made of a basic lining in a roaster furnace and the lining is still in perfect condition. The results were so satisfactory that at the present time the company at whose works the trial was made have nine roaster furnaces with basic lining at work treating arsenical "metallic bottoms," and white metal.

*Description of the Roaster Furnaces.*—These furnaces have a cast-iron bottom plate, air cooled, by means of which the possibility of any fusion action taking place between the basic hearth and its support is prevented, which would be the case were the basic hearth built directly on the ordinary silica arch. The basic material is ground and mixed with tar in the usual way, and the furnace bottom is formed by throwing this material into the hot furnace and burning it on in layers, beating down each separate layer and giving it fire for several hours before applying the next. It usually takes four or five days to burn on a bottom in this way. When the bottom is properly shaped it is seasoned by melting on it some rich copper precipitate or good blister copper. The tap-hole of the furnace is shut by throwing some basic material against it from the inside.

The working of the furnace is conducted the same as the acid furnace, any repairs to the banks being made by throwing some basic material against the place. The repairs are very slight as compared to an acid furnace, the tendency being for the furnace banks to grow rather than to cut away.

It is in the conversion of these metallic bottoms into blister copper of less than 1 per cent. of arsenic that the basic furnaces have shown themselves to the greatest advantage.

The result from trials of 400 tons metallic bottom roasted in basic and sand-lined furnaces show that, assuming the copper in the metallic bottoms to be 84.5 per cent. and the copper in blister to be 98.5 per cent., there was obtained in the form of blister copper 94 per cent. of the copper contents of the bottoms when the basic furnace was used, against 56 per cent. from the acid furnaces, showing a gain of 38 per cent. in favor of the basic furnace. The copper in the slag works out to be 25 tons 14 cwt. in the case of the basic as compared to 121 tons 19 cwt. from the acid furnace. As these figures are calculated from

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averages they are not absolutely correct, but they approximate the true result very closely.

A working charge of metallic bottoms in a basic lined furnace gave the following result: On 7 tons metallic bottoms of 87.4 per cent. copper and 4.6 per cent. arsenic, time of treatment 19 hours, 45 minutes, results:

| | Tons. | Cwt. | Lbs. |
|---|---|---|---|
| Blister copper tapped, | 6 | 19 | 6 |
| Slag, | 1 | 7 | 20 |
| Lime, | 0 | 6 | 20 |
| Fettling, 12 per cent. tar (60 per cent. of this used for the tap-hole), | 0 | 2 | 31 |

Furnace charged 3 P.M.

| Slag. | Time withdrawn. | | Amount of Charges Tons. | Cwt. | lbs. |
|---|---|---|---|---|---|
| 1 | 10 P.M. | | 9 | 1 | 6 |
| 2 | 11.20 P.M. | | 3 | 1 | 0 |
| 3 | 5.30 A.M. | | 7 | 2 | 8 |
| Sample of blister gave at this time. | | 1.42 per cent., As | | | |
| 4 | 10.15 A.M. | | 4 | 2 | 16 |
| Sample of blister gave, | | 1.39 per cent., As | | | |
| 5 | 10.45 A.M. | | 2 | 1 | 8 |

Lime was added to the furnace at 7 A.M., and 10.15 A.M.

*Analyses of Slag Skimmings.*

| | 1. | 2. | 3. | 4. | 5. |
|---|---|---|---|---|---|
| Silica | 18.62 | 5.70 | 6.30 | 6.73 | 6.76 |
| Lime | 19.20 | 14.80 | 17.57 | 23.38 | 20.16 |
| Ferrous oxide | 7.35 | 2.42 | 3.45 | 2.16 | 2.06 |
| Cuprous sulphide | 1.25 | Trace. | 8.50 | 1.50 | Trace. |
| Cuprous oxide | 8.76 | 30.12 | 23.30 | 19.10 | 27.74 |
| Arsenic acid | 11.70 | 23.07 | 20.80 | 35.55 | 31.30 |
| Lead oxide | 24.00 | 12.44 | 7.16 | 2.20 | 2.20 |
| | 90.88 | 88.55 | 86.98 | 90.62 | 90.22 |

In addition to the largely-increased yield of blister obtained when the basic lining is used there is the advantage of less repairs being necessary. The corrosion causes repairs to be made in the acid-lined furnaces every three or four days, and it is partly owing to this fact that the production of these metallic bottoms has nearly ceased in England, the other firms preferring to convert the precipitated copper into sulphide in the smelting-furnace, a better way when no basic-lined furnace is available. It would be far more economical, in the author's opinion, to form these bottoms and treat them subsequently in a basic lined furnace, especially since the metal tapped from the smelting-furnace with the bottoms is far lower in arsenic and other impurities than when no copper bottoms are allowed to form.

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Comparative experimental charges were made of white metal in both acid and basic furnaces, the results showing that there was less slag produced in the basic furnace and that this slag contained a lower percentage of copper than the slag from the acid furnace. The lessened amount of oxidation in the basic furnace resulted in a gain of 26 per cent. blistered copper per hundred pounds of actual copper charged. Two other trials gave 13 per cent. and 30 per cent. gain.

It should be stated that, owing to the arsenic remaining in the bath when the blister arrives at blister pitch, the copper cannot at once be tapped, as is usually the case when low arsenical material is worked, but has to remain in the furnace until a test shows less than one per cent. of arsenic. With ten-ton charges in acid-lined furnaces this takes on an average nine hours after the bath has become blister. In the basic-lined furnaces the time is reduced to about six hours.

Samples taken from the baths of an acid and basic roaster-furnace, just as they became blister copper, gave the following arsenic contents:

| | Basic. | Acid. |
|---|---|---|
| Amount in pimple metal charged, | 2.16 | 1.71 |
| " " bath at blister pitch, | 2.22 | 3.13 |
| " " copper tapped, | 0.78 | 0.90 |
| Hours in furnace after becoming blister, | 6¼ | .10 |

Average analysis of six white metal charges worked in acid and basic furnace:

| | Basic Furnace. Per cent. | Acid Furnace. Per cent. |
|---|---|---|
| Copper, | 75.56 | 76.10 |
| Iron, | 1.54 | 1.30 |
| Lead, | 1.25 | 1.20 |
| Arsenic, | .47 | .51 |
| Sulphur, | 17.44 | 17.80 |
| Oxygen loss, etc., | 1.90 | 1.57 |
| Nickel and Cobalt, | .25 | .18 |
| Phosphorus, | trace. | trace. |
| Silica, | .50 | .35 |
| Alumina, | .50 | .38 |
| Lime, | .42 | .45 |
| Magnesia, | .17 | .16 |
| | 100.00 | 100.00 |

NOTE.—Tin and Silver not determined.

Average analysis of blister copper, tapped from acid and basic furnace:

| | Basic Furnace. Per cent. | Acid Furnace. Per cent. |
|---|---|---|
| Copper, | 97.78 | 78.27 |
| Tin, | .039 | none. |
| Silver, | .024 | .033 |
| Iron, | .026 | .019 |
| Bismuth, | .033 | .035 |
| Lead, | .008 | .013 |
| Arsenic, | .596 | .580 |
| Antimony, | .047 | .028 |
| Sulphur, | .032 | .012 |
| Oxygen and loss, etc., | 1.415 | 1.005 |
| | 100.000 | 100.000 |

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Regarding the removal of antimony in the basic roaster-furnace, trials proved that in treating a considerable amount of arsenical material, 87 per cent. of the antimony was simultaneously removed with 84 per cent. of the arsenic contained in the charge.

To ascertain whether there is any material chemical difference between the refined copper from blister copper treated in the basic- and acid-furnaces, charges of blister from basic and acid roasters were refined in the ordinary sand-lined refinery. Analysis showed that there was no practical difference.

*The Basic Lining Applied to Copper Refining.*—The margin for improvements in the case of the refinery-furnace, when used to produce ordinary tough cake is far less than in the case of the roaster-furnace process; it is, therefore, still a little uncertain whether the extra cost of the initial basic lining and current repairs are compensated for by the slightly increased yield. When, however, it is a question, not of making ordinary tough cake, but of producing best selected copper from ordinary arsenical blister (containing about one per cent. of arsenic) there is, in the author's opinion, a very great saving in waste effected by the use of a basic lining in the refining-furnace. The basic refinery has so far been used chiefly for the production of best selected copper from B. S. precipitate only, or from pure blister containing 0.2 to 0.3 per cent. of arsenic, but some charges have recently been made from blister containing 1 per cent. arsenic which have been worked down into B. S. ingots with very good results as regards yield, but, as might naturally be expected, longer time is required.

As an example of making ordinary tough cake from purely arsenical blister in the basic refinery the following results are given:

Weight of blister charged was 15 tons, 9 cwt., 3 grs.

| Composition. | Per cent. |
|---|---|
| Copper, | 98.150 |
| Arsenic, | .770 |
| Antimony, | .067 |
| Iron, | .078 |
| Nickel, | .029 |
| Sulphur, | .005 |
| Phosphorus, | trace. |
| Bismuth, | .025 |
| Lead, | .011 |
| Silver, | .008 |
| | 99.143 |

The tough cake ladled contained:

| | |
|---|---|
| Copper, | 98.870 |
| Arsenic, | .710 |
| Antimony, | .075 |
| Iron, | .059 |
| Nickel, | .026 |
| Sulphur, | .004 |
| Phosphorus, | trace. |
| Bismuth, | .027 |
| Lead, | .023 |
| Silver, | .009 |
| | 99.803 |

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Weight of slag produced, 1 ton, 5 cwts., 3 qrs.

| Sample dried at 212° F. | per cent. | |
|---|---|---|
| Copper, | 38.15 | |
| Oxygen, | 4.80 | |
| Oxide of lead, | 1.94 = | 1.80 Pb. |
| Oxide of bismuth, | .04 | |
| Arsenic acid, | 2.60 = | 1.70 As. |
| Oxide of antimony, | .22 = | .17 Sb |
| Silica, | 29.84 | |
| Peroxide of iron, | 3.21 | |
| Alumina, | 2.03 | |
| Oxide of manganese, | .15 | |
| Oxide of nickel, | .22 | |
| Lime, | 12.69 | |
| Magnesia, | 3.00 | |
| Sulphuric acid, | .17 | |
| Phosphoric acid, | trace. | |
| | 99.06 | |

Total amount of copper which passed into slag was calculated in this case to be 9.8 cwt., or, per hundred points real copper charged, 3.2 parts passed into the slag. A similar charge in an acid-lined furnace gave, per hundred parts copper charged, 5.1 parts of copper in the slag.

As an example of making B. S. ingots from blister copper rather high in arsenic. The following results are given:

| | Tons. | cwt. | qrs. | lbs. |
|---|---|---|---|---|
| Blister charged, | 9 | 3 | 0 | 21 |
| B. S. ingots ladeled, | 7 | 12 | 1 | 21 |
| Scraps and moulds, | 1 | 7 | 1 | 17 |
| Slag drawn, | 3 | 3 | 0 | 8 |

Composition of the blister-copper.

| | |
|---|---|
| Copper, | 97.77 |
| Iron, | 0.04 |
| Arsenic, | 1.52 |
| Antimony, | 0.02 |
| Tin, | 0.02 |
| Lead, | 0.01 |
| Zinc, | 0.02 |
| Bismuth, | 0.06 |
| Sand, | 0.21 |
| Sulphur, | 0.07 |
| | 99.74 |

Composition of the B. S. ingots produced:

| | |
|---|---|
| Copper, | 99.8 |
| Iron, | trace. |
| Nickel, | " |
| Zinc, | " |
| Lead, | " |
| Bismuth, | 0.02 |
| Antimony, | trace. |
| Tin, | " |
| Arsenic, | 0.05 |
| | 99.96 |

Trace meaning less than 0.01 per cent.

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Average composition of the slags:

| | Per cent. |
|---|---|
| Suboxide of copper, | 33.22 |
| Oxide of copper, | 6.12 |
| Lime, | 16.32 |
| Soda, | 4.77 |
| Magnesia, | 5.81 |
| Oxide of manganese, | 0.14 |
| Protoxide of iron, | 4.05 |
| Aluminina, | 6.97 |
| Oxide of zinc, | trace. |
| Oxide of bismuth, | 0.10 |
| Oxide of lead, | trace. |
| Oxide of tin, | 0.02 |
| Oxide of antimony, | 0.05 |
| Silica, | 16.85 |
| Phosphoric acid, | 0.53 |
| Sulphur, | 0 19 |
| Carbonic acid, | 1.56 |
| Arsenic, | 2.47 |
| Oxygen, etc., by difference, | 0.83 |
| | 100.00 |
| Copper, | 34.67 |

The calculation of the percentage of real copper charged which passed into the slag gave 12 per cent. This high percentage being due to the large amount of arsenic in the charge which had to be removed.

From these results given (which were corroborated by a vast number of others that space did not permit of detailed publication) there is no question as to increased yield resulting from lessened oxidation when the basic lining is used. The acid lining will permit of the removal of impurities, but the waste is much greater. Other tests were made in basic- and acid-lined furnaces, starting with crude metallic bottoms converting them into blister and refining them in both acid and basic furnaces. The results showed that the elimination of antimony and bismuth was more completely effected in the acid than in the basic-furnaces; this is doubtless due to the thin cupriferous slag in the acid-furnace permitting the easier oxidation than the thick calcareous slags in the basic-furnace. The results also showed that the percentage of actual copper slagged off was 11.6 in the case of the basic-furnace against 34.2 in the acid.

Summing up the results so far obtained in basic copper-smelting, show:

1. That it is of most use in the treatment of highly arsenical material tapped from the smelting-furnaces. Such material being produced from the poorer arsenical precipitates generally gives a very high loss of copper in the slags and necessitates extra labor and expense to re-work.

2. That it is also well adapted to the refining of blister-copper rather higher in arsenic (say from 1 to 1.5 per cent. or higher) for the purpose of making B. S. ingots.

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# BOOK REVIEWS.

ANLEITUNG ZUR DARSTELLUNG CHEMISCHER PRAEPARATE. Von Dr. Hugo Erdmann, Privatdocent an der Universität Halle. Frankfurt a. M., 1891. pp. viii. and 71.

IN the study of chemistry it is evident that the student should have practice in the preparation of chemical compounds. In organic laboratories this principle is recognized, and a large part of the student's time is therefore devoted to making a variety of known organic compounds by characteristic reactions, obtaining them in a state of purity and observing their physical and chemical properties. The books of Levy, Fischer and others are designed to aid the student in this kind of work. But when we attempt to apply the principle to the inorganic laboratory we have had till now no single book to which the student could turn for assistance.

The above title is that of a book which is intended to fill this place. The author has collected complete but concise methods for preparing, in a pure state, upwards of eighty inorganic compounds, arranged in a progressive manner and with a partial view to working up some of the worthless residues of the laboratory. The reasons for each step in the preparations are given, explained by equations when necessary, and tests are mentioned by which the purity of the products may be checked.

Among the preparations described are sodium chloride, sodium nitrite, potassium chlorate, cadmium carbonate, anhydrous magnesium chloride, anhydrous ferrous and ferric chlorides, strontium hydroxide, barium oxide and peroxide, pure nitric acid, iodine pentoxide, perchloric acid, crystallized silicium, boron, selenium, metallic manganese, zinc free from arsenic, etc. An appendix of five pages is devoted to the description of some laboratory accessories and to the preparation, washing, and application of gaseous reagents.

It cannot be denied that practice in making such chemical compounds as these ought to be a part of the education of every student of chemistry. Although intended for the laboratory student, this little book may be used with profit by chemists of experience. C. E. C.

LABORATORY PRACTICE. A Series of Experiments on the Fundamental Principles of Chemistry. By Josiah Parsons Cooke, LL.D., Harvard University. D. Appleton & Company, N. Y. 1891. 192 pages. 8vo. Good print, generously spaced, not illustrated.

Chapter I. is devoted to the study of the distinguishing properties of water, air (as an example of aeriform matter) oxygen, hydrogen, sulphur, chlorine, carbon, nitrogen, magnesium, zinc, sodium, copper and iron.

Chapter II. discusses the general principles of chemistry included under chemical and physical mixture and solution; laws of definite proportions by weight and by volume; compounds and elements; and analysis, both qualitative and quantitative.

Chapter III. gives the theory of molecules; physical and chemical methods of determining molecular weights; conception of atoms and determination of atomic weights.

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Chapter IV. is devoted to chemical symbols and reactions; stoichiometry and chemical nomenclature.

Chapter V. discusses the subject of molecular structure, giving experiments on determining quantivalence.

Chapter VI. treats of thermo-chemistry, giving experiments on the heat of hydration; solution; neutralization; chemical action; precipitation and crystallization.

The idea of the author in preparing this work was to provide a chemistry which, with the aid of a teacher, would afford to students a better course of instruction, particularly in experimentation, than is generally given in the elementary text-books and if the text be conscientiously adhered to the student cannot fail to have his ideas on chemical investigation clear and at the same time have acquired skill in drawing deductions from experiments given.

This work being a companion volume to *The New Chemistry*,* many references are made thereto; sufficient material is given however to cover the subjects discussed.

Throughout the work the author presents in detail the various experiments usually performed, emphasizing the salient points by means of well selected questions requiring the student to study the reactions involved, and make the resultant deductions himself—a highly commendable advance in the method of teaching adopted by the majority of text-books.

Although the directions given for the setting up of apparatus for the various experiments are sufficiently clear for any intelligent mind to grasp, the selection of a few illustrations would make the work more acceptable, particularly to those who wish to profit by it and are unable to pursue the course under the guidance of a teacher. J. S.

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EXPERIMENTS FOR STUDENTS IN GENERAL CHEMISTRY. By Edgar F. Smith, Professor of Chemistry, University of Pennsylvania, Philadelphia, and Harry F. Keller, Professor of Chemistry, Michigan Mining School, Houghton. Second Edition, enlarged. With 37 illustrations. Philadelphia: P. Blakiston, Son & Co., 1012 Walnut St. 1891. 8vo. 56 pp. Interleaved.

Every teacher of chemistry who has an enthusiasm in his work, usually finds that none of the numerous available works on the subject give just what he wishes, and sooner or later he conceives the desire, whether he carries it into execution or not, of putting in print his own plan of instruction. Such a proceeding is often necessary, when many students receive instruction under the direction of one teacher.

The book before us appears to be of that kind. It is based chiefly upon Richter's *Inorganic Chemistry*, to which references are made throughout. It is not intended for those who may wish to study without a teacher, much being left for the instructor to explain. The main object is to aid the instructor by suggesting experiments and the methods of making them, which will serve to illustrate the general principles of chemistry without the use of elaborate apparatus. In this way the principles of wet analysis (including volumetric) Stoichiometry, Eudiometry, Specific Heat measurements, etc., are presented to the student.

The introduction of what may be called the "quantitative idea" from

* Also published by D. Appleton & Co.

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the very start is a feature of the book which is absent from many works intended to cover the same ground. Quantity, weight and volume have such an important place in the study of chemical relations that it almost seems strange that in so many text-books of the kind, the attention of the student is almost exclusively directed to phenomena only, leaving the mathematical relations for subsequent work. Professor Ramsay's *Experimental Proof of Chemical Theory* was almost the first in which that method of teaching the subject was brought out, and the enthusiasm with which it was received as an adjunct by scores of teachers, was sufficient proof of the value of the "quantitative idea" in instruction in general chemistry.

The order in which the elements are considered, is the same as that given by Richter, which differs from that followed in analytical work. After the metalloids, in which arsenic and antimony are treated in the group with phosphorus and nitrogen, follow the alkali metals, and between the alkaline earth metals and the iron group (which is put last) are sandwiched the metals of the hydrogen-sulphide group. Arguments as to the advantages and disadvantages of this arrangement might be adduced, but will not here be discussed.

At the end of the book a single page marked "Appendix," gives a few comparisons of the metric units of length, capacity and weight, with those to which Americans are more accustomed, and a table of atomic weights. In the latter, decimals are avoided so far as possible, which makes them sufficiently close for such calculations as are required in the text.

The pen and ink illustrations (which are numerous) are small, but illustrate very clearly the method of working which is recommended in each case, which is more than can be said sometimes for more elaborate illustrations in books of a similar character.

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# THE SCHOOL OF MINES QUARTERLY.

A

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## JANUARY, 1892.

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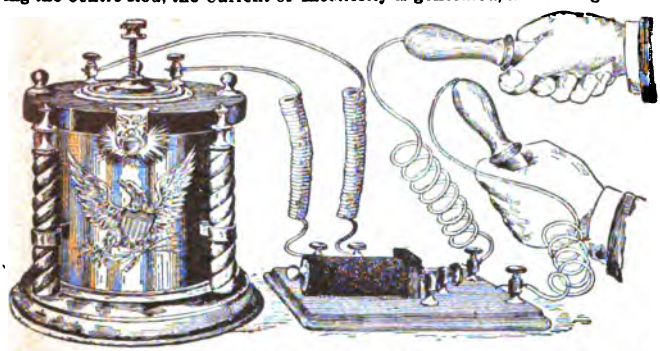

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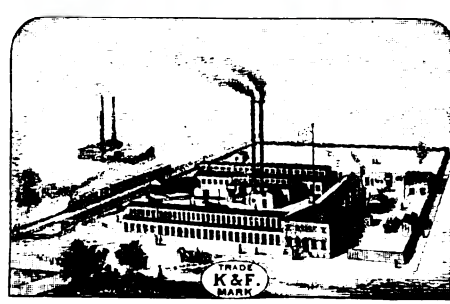


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# SCHOOL OF MINES QUARTERLY.

VOL. XIII. JANUARY, 1892. NO. 2.

## THE VALUATION OF FUEL-GAS.

BY E. G. LOVE.

SOME years ago it was confidently asserted in certain quarters that as the rush-light had been replaced by gas, so the gas in its turn would be superseded by a more perfect illuminant, and consigned to the useful but less important sphere of heating.

The probability of such a change will depend more upon the degree of perfection to which competing illuminants can be brought, than upon the fact that gas manufacturers can be depended upon to occupy the new field assigned them; while the increasing consumption of gas for illuminating purposes can hardly be taken as an indication of the immediate fulfillment of the prophecy.

It is not our present purpose, however, to enter into any defence of one illuminant against another, but rather to consider some of the conditions which a fuel-gas should fulfill, and to what extent these conditions are met in existing gas supplies.

The increasing demand for a gaseous fuel opens a very promising field for the enterprise of the gas engineer; and when we consider the possibilities of the future it must be admitted that this branch of the gas industry is still in its infancy.

The promoters of the various schemes for the manufacture and distribution of fuel-gas have directed their attention more to the production of a gas which can be sold at a very moderate price,



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while in many cases at least they have overlooked the fact that the product they propose to sell must be judged primarily by its efficiency as a heating agent.

The average consumer has no knowledge of the character of the gas he buys, and he will seldom trouble himself to find out. If two gases are offered him he naturally takes the cheaper, and it often happens that he gets less for his money than though he had taken the one costing him more in dollars and cents. What is true of gas as an illuminant will be equally true of gas as a fuel. In the former case it is fair to assume that the consumer employs the proper appliances for burning the gas, and it follows that that gas is most economical that gives the greatest number of candles for a given cost. The same is true of gas as a heating agent. A fuel-gas at 25 cents per thousand feet is no cheaper than another having four times its calorific power at $1 per thousand; and yet very many consumers will take the first as a much better bargain.

It is not customary to sell illuminating gas per candle-power-foot, and yet such a course would be in thorough keeping with commercial practice in other matters. The most that has been attempted in this direction is to fix by contract, franchise, or legislative enactment some minimum limit of illuminating power. In the same way it would be more equitable to sell fuel-gas at a price depending upon the calorific power it possessed.

It is of the first importance that any fuel-gas intended for general distribution should have a decided odor, in order that its admixture with the air may be readily detected. Experience has shown the wisdom of this requirement. Beyond this its valuation should be arrived at on the same basis as in the case of an illuminating gas, that is the number of heat-units which can be obtained for a given cost.

Efforts have been made to introduce as fuels various gaseous products, having little if any illuminating power, and distributed by a special system of mains; but up to the present time results in this direction have not been encouraging. The gas has generally been odorless; and although supplied at a reasonable price its heating power has been low when compared with that of the illuminating gases. Aside from this has been the question of the desirability of duplicating gas mains in the srteets, especially of large cities, where the territory was already covered by competing

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companies. This in certain cases might be advisable, but as a general practice it is not to be recommended.

If the general distribution of natural gas was possible, and we could look to a constant supply in the future, it would doubtless form an important element in arriving at some satisfactory conclusion.

We come then to the question, to what extent can our present supply of illuminating gas be made to answer the purpose of a fuel-gas?

As we shall see, its heating power is all that we can reasonably expect, it possesses a characteristic odor, its distribution is already effected, and the only question is one of cost. It is hardly to be expected that illuminating gas at its present price will be generally used for fuel purposes, although in certain cases it is more economical than coal, and vastly superior to coal in cleanliness and cost of handling. Compared with the cheap fuel-gases it can generally compete with them on even terms, and in some cases is the more economical of the two.

The following are results which I have obtained in practical calorimetric tests of the carburetted water-gas made by the Municipal Branch of the Consolidated Co. of New York. The tests were made from time to time during the past two years; and the figures give the heat-units per cubic foot at 60° F. and 30 inches pressure:—715, 692, 725, 732, 691, 738, 735, 703, 734, 730, 731, 727. Average 721 heat-units. Similar tests of mixtures of coal-and water-gases made by other branches of the same company give, 694, 715, 684, 692, 727, 665, 695, and 686 heat-units per foot, or an average of 694.7. The average of all these tests was 710.5 heat-units, and this, for our present purpose, we may fairly take as representing the calorific power of the illuminating gas of New York. One thousand feet of this gas, costing $1.25, would therefore yield 710,500 heat-units, which would be equivalent to 568,400 heat-units for $1.00.

The common coal-gas of London, with an illuminating power of 16 to 17 candles, has a calorific power of about 668 units per foot, and costs from 60 to 70 cents per thousand.

The various processes for producing a simple fuel-gas claim little or nothing in the way of illuminating power. The gas is made at small cost, and is usually sold for about 50 cents per one thousand feet. Its value as a heating agent depends mainly upon the hydro-

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gen and carbonic oxide which it contains, with sometimes a small percentage of marsh gas and other hydrocarbons.

If gas was sold by weight these fuel-gases could make a better showing in calorific power, but as it is sold by volume and undoubtedly always will be, little can be expected of a gas which has its principal heat-producing constituent—the carbon—in an already half-consumed condition.

The calorific power of hydrogen is 325.5 units per foot, when the latent heat of the aqueous vapor produced is utilized. When the vapor is not condensed it has only 274.1 units. Carbonic oxide gives 324.7 heat-units per foot, its combustion producing no aqueous vapor.

The product obtained by decomposing steam by incandescent carbon as effected in the Motay process, consists of about 40 per cent. of carbonic oxide and a little over 50 per cent. of hydrogen.

This mixture would have a heating power of about 300 units per foot, and if sold at 50 cents per thousand feet would furnish 600,000 units for $1 00, as compared with 568,400 units from illuminating gas at $1.25 per thousand. This illuminating gas if sold at $1.15 per thousand would therefore be a more economical heating agent than the fuel-gas mentioned, at 50 cents per thousand, and be much more advantageous than the latter in that one main, service, and meter could be used to furnish gas for both lighting and heating.

A large number of fuel-gases which I have tested gave from 184 to 470 heat-units per foot, with an average of 309 units. The price charged for the gas however, was in some cases unknown, although presumably as low as fifty cents per thousand.

Some companies have adopted the plan of selling gas to be used for fuel purposes at a somewhat lower rate than that for lighting, and in this way are encouraging its use.

Some calculations based upon statistics collected by *Progressive Age* show that of 362 gas companies in the United States 165, or over 45 per cent , give some reduction to consumers using illuminating gas for fuel purposes. This discount varies from 5 per cent. to over 60 per cent. on the price charged for the gas used for lighting. Eighty-one companies give a reduction of 25 per cent. or more, while the average discount is a little over 24 per cent.

When all things are considered one must admit that the advan-

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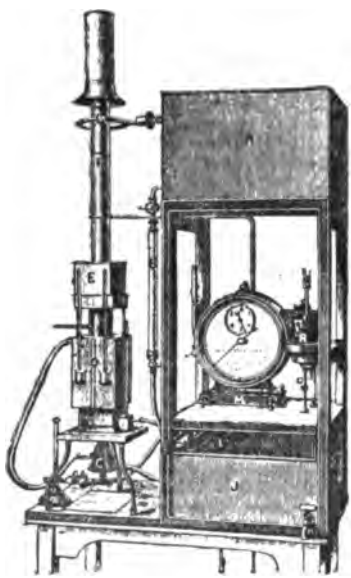
tages of utilizing our present supply of illuminating gas for fuel purposes are very great, and perhaps sufficient to warrant the prediction, that with a cheapening of the cost of production, etc., encouraged by State and Municipal control, the illuminating gas will be made to answer the double purpose of lighting and heating.

The determination of the calorific power of a gas is effected either by a practical test, or by a calculation based upon an analysis of the gas and the determined calorific powers of the constituent gases. The latter course involves the estimation of the several hydrocarbons which are usually grouped under the term "illumi-



nants." This is often a long and somewhat troublesome preliminary, and it is therefore a great saving of time to make a practical test in a properly constructed calorimeter.

The accompanying illustration shows the apparatus employed in determining the calorific powers referred to in this paper, and is one of several forms of calorimeters which of late years have been devised for the especial determination of the heat of combustion of gases. Although it has been described elsewhere, it is hoped that it is of sufficient interest in this connection to warrant a repetition.

It was devised by the late Mr. F. W. Hartley of London; and

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while it does not claim the same degree of refinement as that of Prof. Julius Thomsen, I have found it simple in construction, easy of manipulation, and sufficiently accurate for all ordinary work.

I may say that the calorific powers here mentioned refer to the pound-Fahr. unit, which I think is more familiar than the pound-Cent. unit, or than the more scientific kilogram-Cent. unit or calorie of the French.

The calorimeter involves the determination of the quantity of heat imparted to a small stream of running water by the combustion of a definite quantity of gas, and the subsequent weighing of the water so heated.

In the illustration A is a lead-lined tank for the water supply, whose outlet B is composed in part of a glass tube containing a delicate thermometer for indicating the temperature of the "inlet" water. M is the gas-meter which registers $\frac{1}{20}$ cubic foot per revolution; R a delicate governor connected with the outlet of the meter, and from which the gas passes to the burner.

The combustion of the gas is effected in a Bunsen burner, having an adjustable air supply, and which is surrounded by the conical water-jacket C, through which the water from the tank passes before entering the "body" D. The object of this jacket is to absorb any heat which may be reflected downward from the flame, which however is placed wholly within the body of the instrument.

The "body" is a modified Coffey's still, presenting internally a large surface for the absorption of heat. The water entering at the top, and descending over the heated surfaces finds an outlet by the tube shown at the bottom and right of the "body," where its temperature is again taken. The difference between the reading of this thermometer and that at B gives the number of degrees the water has been heated.

At the side of the tank J is a three-way cock by means of which the escaping water can be allowed to run to waste while the gas and water supplies are being adjusted, and diverted to the tank when the test begins.

A small thermometer placed horizontally above the "body" D gives the temperature of the products of combustion which escape by the tube F. The ring-burner, G, by heating the upper part of F produces the necessary upward draught, which could not be produced by the products of combustion since they pass from the

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combustion chamber at a temperature below that of the air. The box E is for an anemometer.

The thermometers used are graduated in tenths of a degree, and are required for ascertaining the temperature of the air, the inlet and outlet water, the gas, the products of combustion, and the "body" of the instrument. The last are seen fixed to the side in small pockets. The air thermometer is best read by means of a telescope, the others by an ordinary hand-glass.

In using the apparatus the gas is burned at the rate of about 1.5 cubic feet per hour, and 0.25 cubic foot is burned in each test, which lasts from ten to fifteen minutes.

The water supply is regulated by the cock at the upper end of B, so that the increase of temperature in passing through the calorimeter shall be seven or eight degrees Fahr. While these adjustments are being made the water runs to waste, but at the starting of a test the flow is diverted into the collecting tank. During the test the "outlet" thermometer must be read frequently. My practice is to read it four times during each revolution of the meter, or a total of twenty readings, while each of the other thermometers is read once during the same time.

At the end of the test the water is turned to waste, that collected in the tank is weighed, or, as I find more convenient, is measured at a known temperature, and its weight calculated.

The weight of water in pounds, multiplied by the increase in temperature of the water, and divided by the corrected volume of gas burned, gives the calorific power per cubic foot of gas.

This result is subject to two slight corrections which must be made on the figures obtained for the 0.25 foot consumption. 1st. Absorption of heat from the air by the "body" of the instrument. This has been found to equal 0.025° per minute for each degree that the "body" is below the temperature of the air. 2d. Loss of heat by the heated water receiver. This equals 0.01° per minute for each degree that the receiver is above the temperature of the air.

One correction partly offsets the other; and I have seldom found the total correction to exceed one per cent.; usually it is much less.

As an example I give the following test of the gas of the Municipal Branch of the Consolidated Co:

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| | | |
|---|---|---|
| Barometer, | 29.886 | in. |
| Temperature of gas burned, | 66.00° | F. |
| Temperature of the air, (a), | 65.98° | F. |
| Temperature of the water, inlet, (b), | 61 605° | F. |
| Temperature of the water outlet, (c), | 69.275° | F. |
| Temperature of the water, raised, | 7.670° | F. |
| Temperature of the "body," (d), | 63.795° | F. |
| Temperature of the escaping gases, | 64.43° | F. |
| Duration of test, | 12.78 | M. |
| Gas burned, | 0.25 | cu. ft. |
| Gas burned, corrected to 60° F. and 30 in. Bar., | 0.2452 | cu.ft. |
| Pounds of water heated, | 23.228 | |

Corrections:

(a—d) 2.185 × .025 × 12.78 = 0.698° gain.
(c—a) 3.295 × .01 × 12.78 = 0.421° loss.

0.277° gain.

23.228 × 7.67 — 0.28 = 177.88 ÷ .2452 = 725.3 heat-units at 60° F. and 30 in. Bar.

---

## THE TEN-INCH FAUTH DIRECTION INSTRUMENT.*

BY J. T. MONELL, C.E.

THE 10-inch Direction Instrument constructed by Fauth & Co., of Washington, for the Geodetic Department of the School of Mines, Columbia College, is, in its general features, very similar to the 8- and 12-inch theodolites made by the same firm for the United States Coast Survey.

The instrument may be divided conveniently into three parts. First, the spider-like trio of legs surrounding a hollow, upright column. This part forms the base of the instrument, and admits of no motion other than levelling. Second, the horizontal limb or plate. This plate carries a finely graduated circle, for measuring horizontal angles, the prime object for which the instrument is constructed. This part of the instrument is designed to be placed approximately at any desired setting, at which it remains until the required number of angles has been measured upon it. Third,

* Memoir prepared for the Department of Geodesy.

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the alidade, consisting of a telescope and reading microscopes, with their standards supported upon a hard bronze spindle, rotating in a socket formed by the upright column just mentioned.

The telescope is provided with a vertical circle for measuring the zenith distances of objects. Both the circles are free from any danger of strain from clamps, which are attached to their axles only. The materials used in the instrument are mostly brasses and bronzes.

The theodolite rests on a light braced tripod made of wood, with fixed legs, and a circular top of sufficient size to support the instrument and leave some room to spare. The foot-plates are fastened on the top of the table. These are three small metal discs, each with a broad V-shaped groove pointing towards the centre of the stand. There is a large hole in the middle of the table for the plumb-line to pass through.

The base of the instrument is formed by three legs, which support the main socket, while the latter carries all the rest of the theodolite. The legs are hollow, and project from a central ring or boss, upon which rests the main axis. The legs are supported at their outer ends by large milled-headed levelling screws, with rounded points to rest in the grooves of the foot-plates.

These screws are sufficiently fine (36 threads to the inch) to allow of accurate levelling; and the ends of the legs in which they run, are split, and fitted with capstan-headed screws, so that they may be tightened at pleasure. The feet of the three leveling screws form the vertices of an equilateral triangle, each screw being nearly five and one half inches from the centre of the instrument, thus giving the whole a firm base, which is quite necessary in any theodolite. The central boss from which the legs spring, has an inner shoulder inside of which the main socket fits, the lower part of the socket passing through the boss. (Fig. 1.)

A convenient feature of this instrument, is the handle that has been added to it. This is a $\frac{5}{8}$-inch tube bent into a circle, which is placed horizontally, midway between the plate and the legs, and is fastened to the latter by three short, knee-like, brackets, through holes in which it passes. (Fig. 1.). This makes a very convenient and secure handhold that is of great value in handling such a heavy instrument. This idea seems to have been adopted from German makers, and is very well worth applying on all instruments of this class, the additional weight required being insignificant.

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The central upright axis consists of three separate parts; the main fixed socket, which is attached to the boss of the base; the long solid spindle fitting inside of this, that carries the telescope and the microscopes; and the outer sleeve, called the plate axis, which bears the horizontal plate or limb. (Fig. 1.)

The main socket fits into the base and has a broad-eared flange which rests on the face of the boss, to which it is fastened by four screws. The plate axis is a short, tapering sleeve revolving on the main socket, on the outside of which it bears, the upper and the lower inch of its length fitted, and the middle one left loose. It also rests on the flange of the main socket. Clamps are fastened to each of the two ears of the socket flange, and bind on the narrow flange at the base of the plate axis, by means of large capstan-head screws, which pass through the clamp and into the ears. When these binding screws are loose, the plate may be rotated freely, and when tightened, it is held firmly to the main socket in the position desired. The upper part of the sleeve is quite thick, and a deep shoulder is cut away for the plate to rest on, and a little further down, a rectangular groove is turned out, to receive the ring of the horizontal clamp. Neither plate nor plate axis can be removed, without first taking out the alidade. The tops of the main axis and the plate axis, and upper surface of the limb, are in the same plane, while the alidade spindle projects slightly above them—enough to allow the standards to revolve freely, without touching them.

The phosphor-bronze alidade spindle is a little over ¾ inch in diameter, and 5 inches long. It tapers at an angle of 22° for the upper inch, then is straight to the lower end which is tapered off at a still greater angle. The tapered portions are the sole bearing surfaces, and are carefully fitted by grinding, while the straight part is loose in the socket. This supremely important part of the instrument, is very well made, carrying the heavy alidade rigidly, but with a beautifully smooth and easy motion. A small screw, passing through a washer and screwing into the foot of the spindle, holds the latter firmly down against the bottom of the main socket. The weight of the alidade is sufficient to perform this duty under ordinary circumstances, but this screw secures it from danger in travelling if overturned. The head of the screw is formed into a hook, from which the plumb-bob is suspended.

The 10-inch horizontal limb fits over the end of the plate axis,

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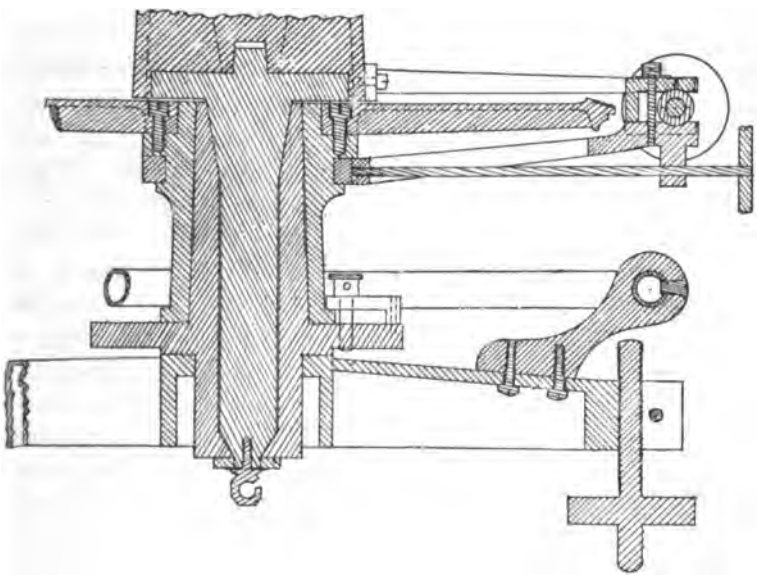
and rests on the shoulder previously mentioned, to which it is fastened by four screws whose heads are sunk into the plate flush with its upper surface. (Fig. 1.) The limb consists of a continuous plate of bronze, strengthened by radiating ribs below, and having its outer edge raised slightly above the rest of the plate, and bevelled to form a conical surface, on which the graduations are engraved. The central portion of the plate, which bears

FIG. 1.



against the shoulder on the axis, is thickened below, and the edge is strengthened by an ornamental rim turned upon it, directly under the graduated surface. This method of construction allows the plate and ribs to be made very light without danger of flexure or want of sufficient rigidity.

The circle is divided into five-minute spaces, and the divisions are cut on a solid silver ring inlaid in the bevelled edge of the plate. The graduations on this instrument are defective in several ways. They are engraved too deeply, which causes an annoying gleam from the sides of the cut, and makes it difficult to bisect a division with the micrometer wires, especially when the illumination comes entirely from one side. The lines are not straight and are of uneven depth, generally being heavier at their

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inner ends than at the outer. It is also difficult to distinguish the divisions apart. They are numbered every ten degrees, from 0 to 360, and the five-degree and thirty-minute divisions are made longer respectively than those corresponding to single degrees and five minutes, the degree divisions being considerably longer than either the five- or thirty-minute ones. But, although this last difference is well marked, the others are so small that is is difficult to recognize them with certainty, and it will generally be found necessary to count the degrees from the last numbered division, and the minutes from the last degree division.*

The telescope standards are of the U-shaped type; with the exception of the upper three inches, the whole is in one casting, consisting of two U-like ribs, joined at their inner edges by a broad web, and tied together by several transverse braces. (Fig. 2.) The ribs are quite near together at the top, and gradually separate towards their base, which is wide and very strong. The manner of attaching this wye-frame base to its spindle, is important. The latter terminates in a circular plate, 3 inches in diameter, and about three-eighths thick, and a short conical head truncated, and of about a half inch diameter. The lower portion of the standard is a strong square box, open at the bottom, and fitting over the circular head, and almost concealed by the smooth curved inner surface and sides of the wye-frame. Projecting down into the box from its top, is a hollow cone, which receives the conical centre of the spindle; while stretching across the box at right angles with each other, are two vertical webs, cast in the same piece as the rest of the standard, and cut away so as to fit snugly over the large spindle head. Four large screws pass up through the head, and into these cross partitions, which are thickened to receive them. In this way, the fastening of the spindle to the alidade, is made very firm. The upper parts of the standards are secured to the lower by two screws in each piece. The whole frame has a height from the wyes to the top of the base, sufficient to give the telescope a clear swing of 8½ inches. The telescope pivots rest in the wyes, on the tops of the standard uprights.

The wyes are triangular notches across the tops of the standards,

* Since this description was written the graduations have been remade entirely. Messrs Fauth & Co. have put in a new set of graduations with microscopic figures at every degree. This new graduation is exceedingly satisfactory.—J. K. R.

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each of the two sides of the notch having a small agate plate inserted in it, held in by a mortise at one end, and a small brass

FIG. 2.

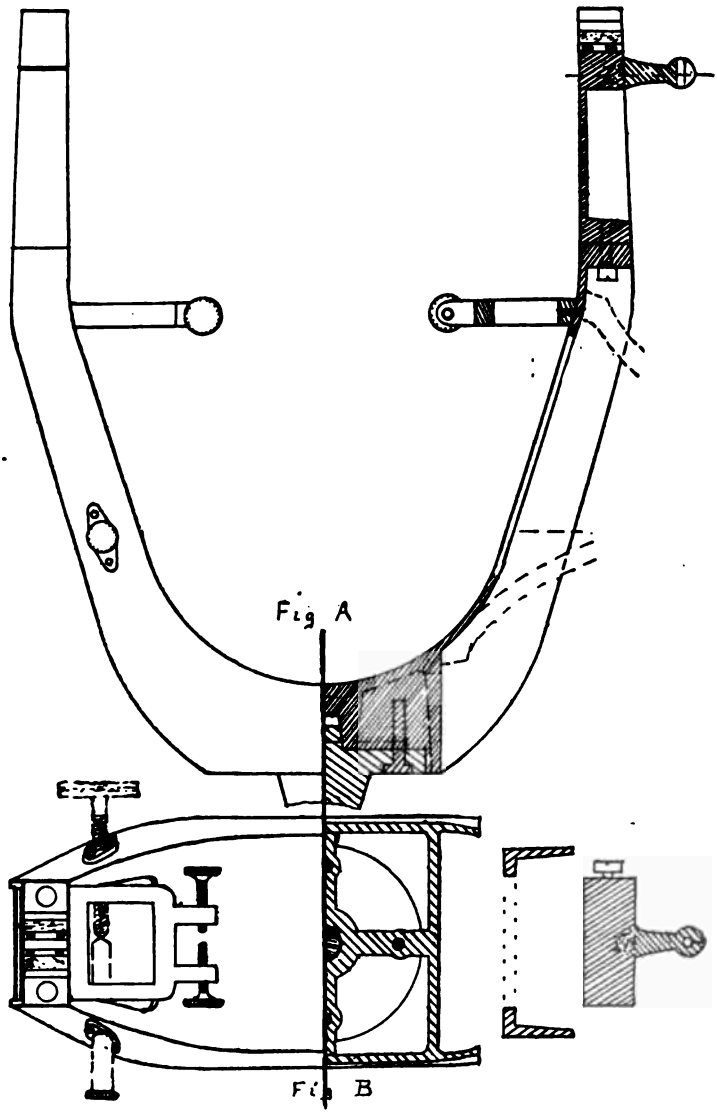


plate at the other. These pieces of brass are held in with a couple of small screws. On these agate surfaces the journals of the hori-

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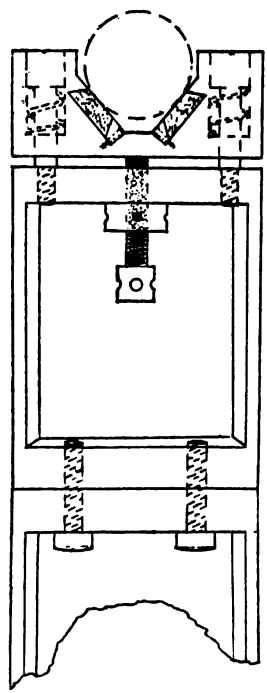
zontal telescope axis rest and turn. In order to raise or lower one end of the horizontal axis, one of these wyes is made adjustable with regard to height. The extreme top of the upright, containing the wye, is a distinct block joined to the lower part by screws which thread into the latter, and is continually pressed down by a coiled wire spring under the head of each screw. Coming up through the fixed part of the upright, and bearing on the lower side of the adjustable wye-block, is a capstan headed screw. When

FIG. 3.



this is tightened, it forces the wyé-block up; when loosened the springs press the wye-block down. (Fig. 3.) The screw has a jam nut to keep it in the desired position. The supports of the micrometer microscope project from between the ribs of the standard directly outward.

The theodolite has two small levels for the rough levelling of the instrument. The larger of these is placed alongside the base of the standard. The other one is fixed at right angles to the first, and parallel to the plane of the telescope. It is about half way

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up one of the uprights; and on the inner side, which protects it from accident, but makes it rather troublesome to read, especially as it is situated directly below the clamping bracket of the telescope level. These plate levels are supported at their ends by small brackets attached to the standards; and each has a capstan headed screw for adjusting it. They are about 3 inches long, and rather coarse, in fact no better than those often supplied to a good engineer's transit. There is a light metal guard at the base of the standard, to prevent the telescope striking the lower level tube.

The horizontal circle is read by means of a pointer and two micrometer microscopes; marked respectively A, and B, the reading to the last five minute division passed over being obtained from the pointer, and the additional minutes and seconds from the microscopes. The pointer consists of a small arm, projecting from the supporting frame of the telescope, at its base. The reference mark of the pointer is engraved upon its outer edge, which is bevelled at about the same angle as the graduated portion of the limb, and silvered; and the length of the arm is such as to bring the outer end of this mark directly over the inner ends of the graduations. The pointer is read by means of a microscope, which consists of a single lens mounted in a short brass tube, and is held in position over the outer edge of the pointer by a swinging arm attached to the pointer arm. The microscope tube slides in its mounting to allow for focusing. The pointer arm is attached to the telescope frame by two screws passing through holes in its inner end, which is bent up at right angles to the rest of it for this purpose, the holes being made sufficiently large to allow the screws some play, and enable the distance of the pointer from the limb to be adjusted. There is necessarily considerable parallactic displacement in an arrangement of this kind, since the end of the mark cannot be brought down upon the graduations without scratching the limb.

The microscopes are of the ordinary form of compound microscope with achromatic objectives and positive eye-pieces. The objective consists of a double achromatic combination of long focus, and the eye-piece contains two plano-convex lenses, having their curved surfaces toward each other, and is of low power. The body of the microscope is composed of two pieces of brass tube, of about three-quarters of an inch in diameter, screwed into

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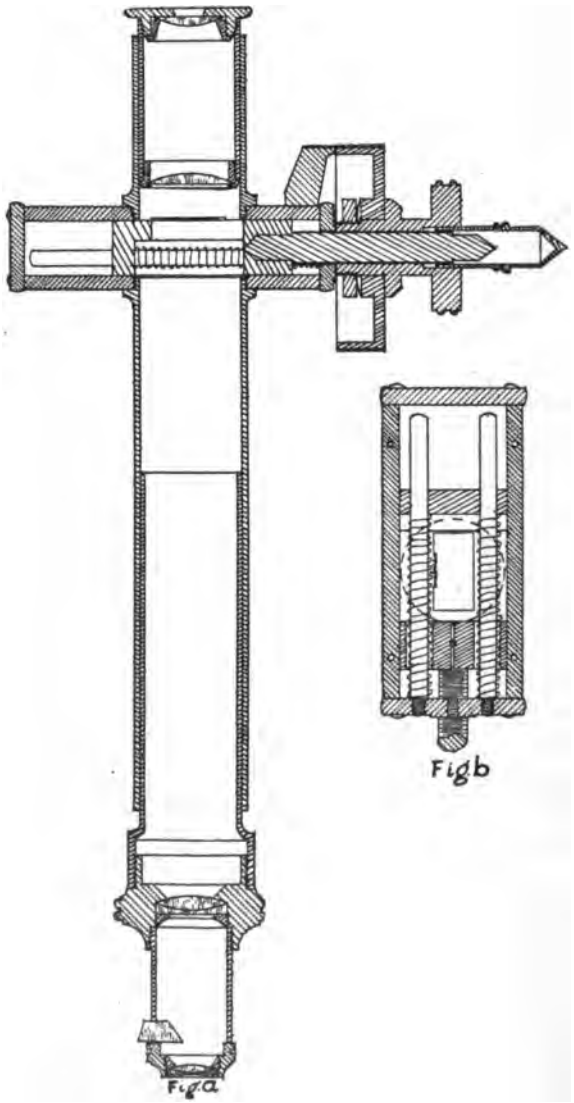
the opposite sides of the rectangular brass micrometer box placed at the common focus of the objective and the eye-piece, the pieces

FIG. 4.




of tubing being of a proper length to give it this position. (Fig. 4.) Directly beneath the upper plate of the box (the one nearest the eye-piece) on one side of the field of view, and limiting it in

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this direction, there is attached a thin brass plate with a row of projecting teeth on its inner edge. The middle point of the scale thus formed is marked by a deep notch terminating in a small hole. Inside of the micrometer box, there is a sliding frame, having a rectangular hole cut through it. Across the upper surface of this frame, two parallel spider lines are stretched and fastened perpendicular to its line of motion; and the position of the sliding frame is such that the spider lines play directly under the serrated scale. The ends of the frame are thickened into blocks which project below the rest; and into one end of it, a threaded steel rod, which projects through the end of the micrometer box, is fastened by means of a pin. Two parallel guide rods are threaded into the same end of the box, in such positions that they pass below the body of the frame, and through holes in its end, they being sufficiently long to extend through to the other end of the box. Each of these rods is surrounded by a spiral spring, which bears against that end of the micrometer box into which the rods are fastened, passes freely through the hole in the nearest end of the sliding frame, and presses against the other end of the latter. The frame is held in position against the pressure of these springs by the micrometer head, which is screwed upon the projecting end of the threaded rod, and bears against the outside of the micrometer box. The micrometer head consists essentially of a long nut provided with a milled head for convenience in turning it, its length being sufficient to admit of the micrometer wires being drawn entirely across the field of view by screwing it up without the screw striking against the end of the nut. A shoulder is turned upon it, near its inner end, which is threaded to carry a small nut; this nut bears against a spring washer, which, in turn, presses a disc against the shoulder. The disc forms the end of a short brass cylinder whose rounded surface is cased in a thin silver ring. The silver cylinder is divided into 60 equal parts, the graduations extending to the end of the cylinder nearest the micrometer box, where they are read by the aid of an index mark engraved upon a smaller silver plate, which forms part of the same cylindrical surface, and is borne on the end of a projecting arm attached to the top of the box. The pitch of the micrometer screw is such that one turn of the head carries the micrometer wires over the space between two adjacent notches on the serrated scale. When the microscopes are in adjustment, this distance also corresponds to



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the image of one minute of arc measured upon the graduated plate; and as the head is divided into 60 parts, one division of the head corresponds to a single second of arc. The serrated scale serves to show how many whole turns of the micrometer head the wires are distant from the centre of the field. The graduated portion of the head is attached to the rest by the friction device, as previously described, instead of a more rigid connection, to enable the wires to be held in any desired part of the field, while the graduated cylinder is turned to read zero. The objective and the eye-piece are mounted in separate brass tubes, which slide inside of the body of the microscope to allow for focusing, and the correction of parallax.

The microscopes are attached to the standards of the telescope by frame works which consist of two pieces. (Fig. 5.) First, a bracket consisting of a flat piece of brass, about one inch wide and two long, from each end of which a curved arm of the same thickness springs inwards towards the the telescope frame, where it is attached to the web by two screws. The pieces curve away from each other, and are widened as they approach the web—a style of construction which gives great rigidity with a comparatively small amount of metal. The second part consists of a flat piece of brass, similar to that on the first, at the ends of which at right angles to its length, there are two short arms, of the same width and thickness, which are formed into collars through which the microscope passes. The outer side of each collar is split, and provided with projecting lugs, through which a capstan-headed screw is passed to clamp the collar firmly about the microscope. After loosening the screws, the microscope may be turned around in the collars to make the micrometer wires parallel to the graduations on the limb, or raised and lowered to adjust the run. The flat surfaces of the two parts of the microscope-support are drawn together by two capstan-headed screws, one placed vertically above the other, and are kept apart by a small round rod placed horizontally midway between them, brazed into a shallow groove in the microscope-piece, and resting in a corresponding groove in the other surface. This rod thus acts as a fulcrum about which the microscope and piece attached to it may be turned, by loosening one of the screws and tightening the other, in order to place the axis of the microscope perpendicular to the element of the graduated surface directly under it. In addition to this arrangement, the part attached to microscope B has screwed into it, and, pro-

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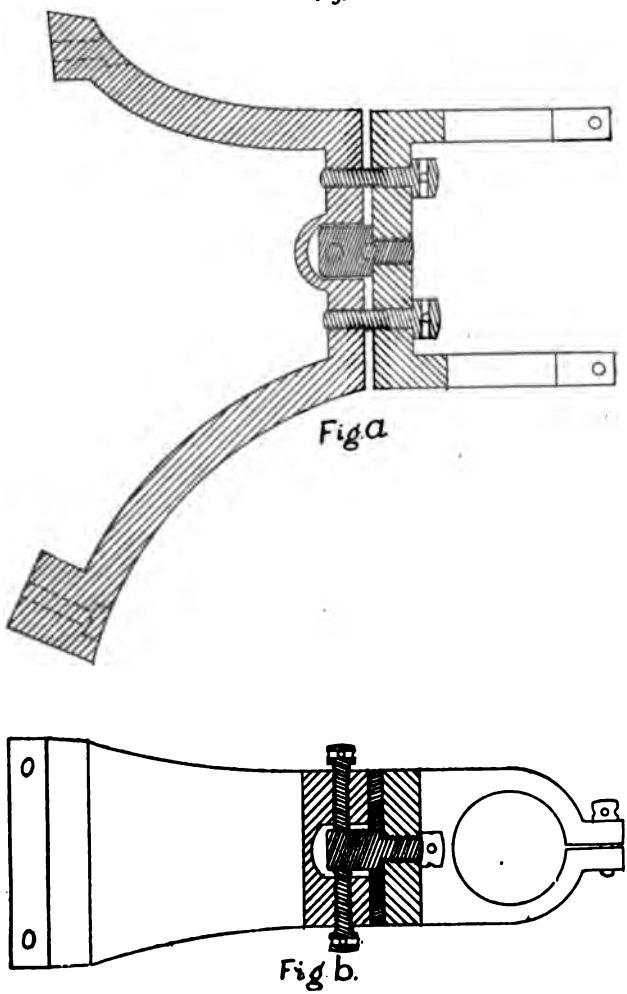
jecting from the flat surface at the middle point of the brass rod, a short piece of steel having its two opposite sides squared. This piece projects into a horizontally elongated hole in the face of the

FIG. 5.




bracket, where it is clasped between the two opposing capstan-headed screws which enter the flat piece, here thickened to receive them, from the sides. It is evident, that by loosening one screw and tightening the other, microscope B may be moved horizontally, enabling it to be placed 180° distant from microscope A.

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This construction is somewhat novel; the adjustment of the angular distances between the zero points of the micrometers usually having been allowed for by making the serrated scale in each micrometer box adjustable by a screw, which enters through the end of the box opposite the head, and pulls the scale against the action of a spring, while the microscopes themselves were fixed. It is claimed that the arrangement of the single movable microscope preserves the adjustment more permanently than the old style; and it also possesses the advantage that the zero of the micrometer-scale is permanently fixed in the centre of the field of view, causing all the bisections to be made near this point, a condition favoring accurate work. It is to be observed, that in this instrument all the adjustments of run, focus, and parallelism of micrometer wires, have to be made directly by the hand, as no screws are provided for this purpose, and it is almost impossible to obtain an accurate adjustment in this way.

The method used in this instrument for illuminating the graduations under the microscopes, is also of rather recent application. A small square plate of white porcelain, backed by one of brass, is attached by a ball-and-socket joint to the end of a short brass tube which projects from the side of the box at the base of the telescope-supports. Directly opposite this plate, a small totally-reflecting prism is let into the side of the objective tube of the microscope, between the two lenses, so that it throws the light, reflected from the porcelain surface, down through the lower glass of the objective upon the limb. The makers claim that this method of illumination is superior to the old form: but, as the microscopes are not provided with shade-tubes, there is nothing to prevent a side light from falling upon the limb, which is particularly annoying in this instrument with its deep-cut graduations.*

One of the best features of the instrument is the horizontal clamp and tangent screw. The clamp consists of a collar, made in two pieces, held together by screws passing through projecting lugs, which fits around the groove in the plate axis. In the middle of the inside surface of one section of the collar, a square notch is cut, into which is fitted a movable brass block, whose ex-

* The microscopes are now supplied with glass cylinders, which reach from a point a little above the objective to the plane of graduations. Inside of this glass cylinder is a lining of thin white silk; the light is diffused as it passes through this lining, and the illumination is most perfect.—J. K. R.

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posed surface is cut to form a portion of the same cylindrical surface as the rest of the ring. A steel screw of sufficient length to project beyond the edge of the plate, and provided with a large brass head enters the ring from the outside, and when screwed up presses the movable block against the plate axis, clamping the collar firmly in place. This kind of clamp bites very firmly, and avoids all travelling action. (Fig. 1.) From the same section of the collar in which the clamp-screw works, and situated on opposite sides of the latter, two arms project, sloping upwards and towards each other, till just before emerging from beneath the plate, where they unite and extend about an inch beyond its edge. Near the end of the arm, and projecting downwards, there is a lug, through a hole in which the clamping-screw passes; and in the upper surface of the arm, directly above the lug, a small cavity is made. Attached to the arm by means of a capstan-headed screw there is a piece of brass, in the form of two small flat plates at right angles to each other, one of which rests upon the top surface of the arm, while the other is parallel to this surface. In the lower surface of the parallel plate a cavity is cut corresponding to the one in the surface of the arm. A split, spherical bronze nut, in which the tangent-screw works, is held between the upper surface of the arm and the lower surface of the plate, and is kept in position by being fitted into the two cavities. It is prevented from turning by a short pin which fits into a hole in the attached piece. A projecting arm, attached to the base of the telescope-standards, is provided with a similar cavity and clamping-piece upon its lower surface, the two cavities in this case serving to hold a spherical projection which is turned upon the shank of the tangent-screw. The tangent-screw has no longitudinal motion apart from this bearing, but turns freely in it. The screw is of bronze, has 100 threads to the inch cut upon it for a distance of 2½ inches, and is provided at each end with a head of large diameter. One turn of the screw corresponds to about five minutes of arc, and with the large heads provided, a very slow motion may be obtained.

The horizontal axis is made of phosphor-bronze, and carries the telescope in a boss, which forms its middle part. (Fig. 6.) The axis consists of two irregularly conical arms screwed into the central boss. The arms terminate in journals, turning in the wyes, and are enlarged just inside of these bearings, to receive the vertical clamp. The boss is perpendicular to the axis, and there is a

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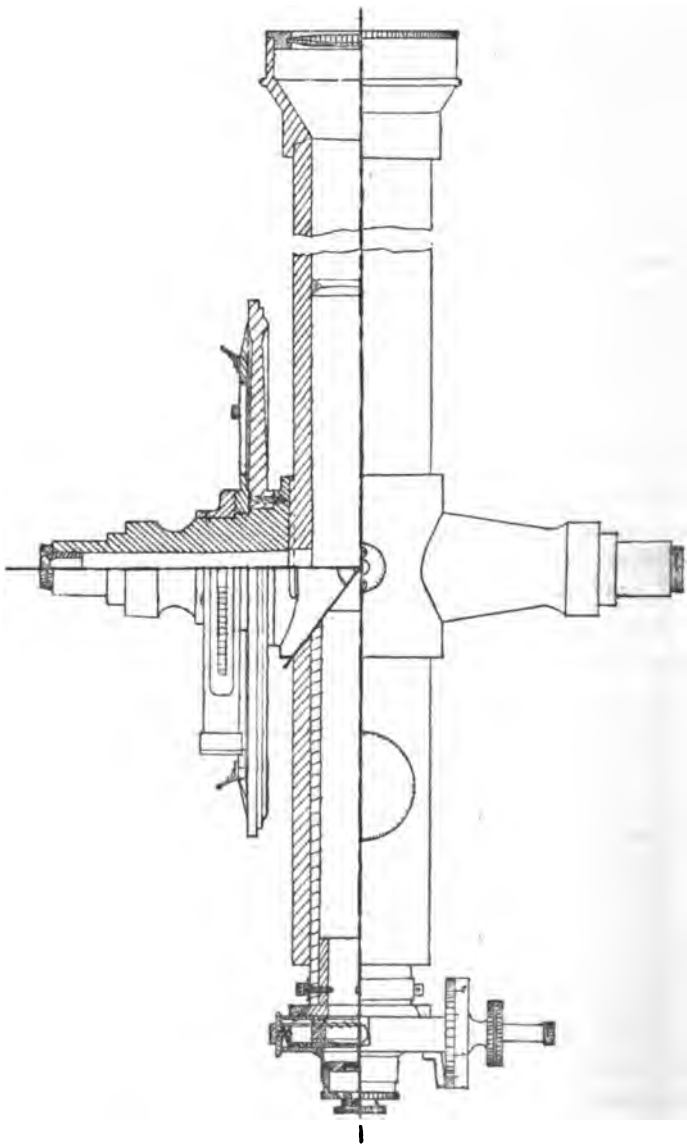
sleeve fitting inside of it, into which the two sections of the tele-

FIG. 6.



scope tube are screwed, and which is fastened in the boss by a couple of screws.

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The vertical circle fits the axis tightly and is fastened by four screws to the boss, which is thickened and faced to receive it. The circle thus partakes of all the movements of the telescope and axis. The verniers, on the contrary, turn freely on the axis, but are held in place by a collar, which is screwed to the axis so near the vernier hub as just to touch it; the pressure necessary to keep the verniers against the circle being obtained by a thin brass ring inserted in a groove turned in that face of the collar next to the vernier hub. This ring is slit in several places, and portions are bent up so as to form a sort of spring, which bears against the hub.

The telescope is held on the standards, and its vertical notions controlled, by a "Davidson" clamp. When the clamp is opened, the telescope may be taken off the standards and put back with the same pivots in different wyes; and it may also be rotated through, between the standards without taking it out—only loosening the clamp nut,—the standards being just high enough to allow the eye-piece end of the telescope to swing through. When either the cap or the sunshade is on the telescope, it is so nearly balanced that it will stay in place when left unclamped.

The Davidson clamp consists of a long lever arm, loosely pivoted close to the inner side of one of the uprights, and supporting a collar which closes around that enlargement of the horizontal axis already mentioned. (Fig. 7.)

This collar is in two parts, hinged together, and locking shut by a milled head nut running on a short screw that pivots in a slot in the end of the lower half, and swings up, in order to clamp, through a corresponding slot in the upper part of the collar.

The slow motion is given to the clamp and telescope by a fine screw, and opposing cased spring, which work through the open lower part of the standard, against the lever arm. This screw is quite delicate enough for use in taking vertical angles, but unfortunately it gives the telescope a slight motion in azimuth, so that if a small object be bisected by the vertical threads, and then four or five turns taken with the screw, the threads will move quite appreciably to one side. This renders it necessary to measure horizontal angles with the clamp free, bringing the horizontal wire into position by hand; but does not cause any trouble in altitude work.

The telescope has a magnifying power of about 32 diameters.

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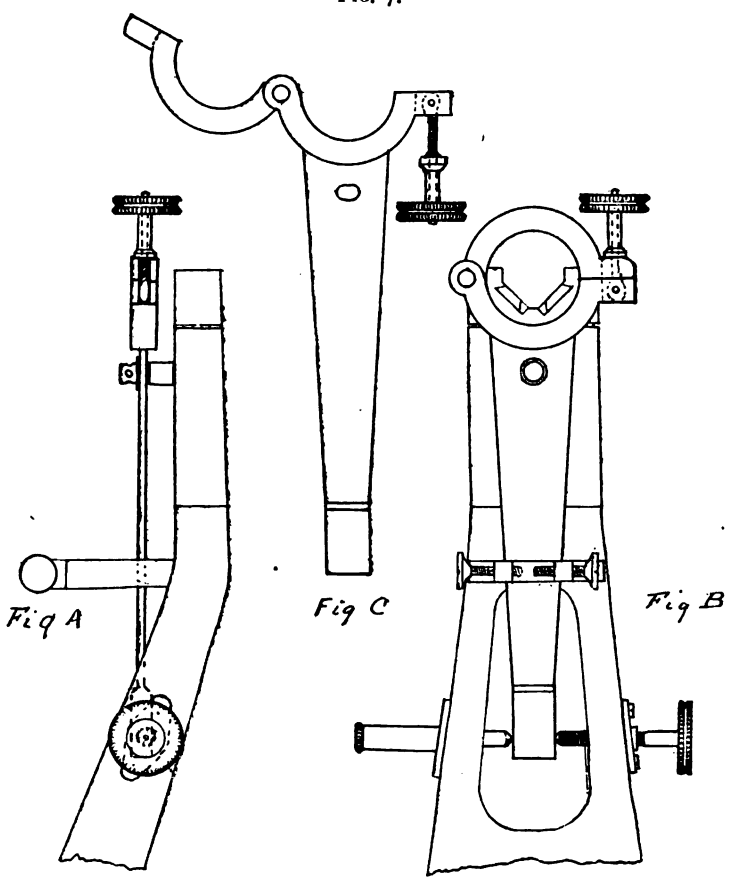
It has a two-inch achromatic objective, with a focal length of nearly 16 inches. The objective is mounted in one section of the main tube, and the other section contains a shorter tube carrying the micrometer eye-piece, and sliding into it by a rack and pinion motion of about two inches, enabling an object within 25 feet to

FIG. 7.




be brought into focus. The back of the micrometer box has a couple of flat parallel bars screwed across it, forming ways which fit over the bevelled edges of a flat plate. By turning two opposing capstan head screws, bearing on the opposite sides of the box, it, and the attached eye-piece, can be slid across the field. This provides the means of bringing the centre of the eye-piece, with

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the fixed thread, into the line of collimation. This slide plate is on the end of a short tube which fits in the long focusing tube, and which is capable of being rotated through a quadrant, carrying with it box and eye-piece, so that the horizontal thread will then be vertical, and *vice versa*. This movement is made by taking out the two capstan headed screws which hold the short tube in place, turning the tube, and then putting back the screws in another pair of holes 90° from the first. The eye-piece proper is of the Steinheil pattern. Both lenses are achromatic, and their four exposed surfaces are all convex. This form of positive eye-piece is used on account of giving a very flat field. It is focused by hand only, fitting in a short tube which is mounted directly on the micrometer box. There is a small cap with a dark glass, for sun observations, and there is also a diagonal eye-piece for high angle work. This latter screws into the box in place of the ordinary eye-piece, the thread being cut on a swivel coupling, so that the eye-piece may be rotated anywhere in a plane perpendicular to the optical axis of the telescope. The eye-piece consists of two tubes fastened at right angles to each other, each containing a pair of lenses. The pair in the shorter arm, which fastens to the micrometer box, throws the image upon the inner face of a right angled glass prism, which reflects it through the other pair to the eye. There are a number of adjusting screws to hold the prism in proper position.

The eye-piece micrometer differs somewhat from the microscope micrometers, although the arrangement of the head, the long screw, the springs, and the sliding frame is very similar. The toothed scale, however, is not fixed, but is mounted in a frame that may be adjusted by a short screw passing through the end of the box, and screwing into the frame, and working against a short spiral spring. The scale is placed between the reticle and the eye-piece. The silvered head is divided into fifty equal parts, the value of each part being about 2.5 seconds. The reticle is composed of one horizontal and two close vertical spider threads, the former fixed and the latter moved by the head, with their sliding frame. This micrometer eye-piece is intended: first, to obtain the angle between two objects, both in the field of view; and second, to increase the accuracy of ordinary angle measuring, by making a number of bisections with the threads, and taking the corresponding readings of the head, for every pointing of the

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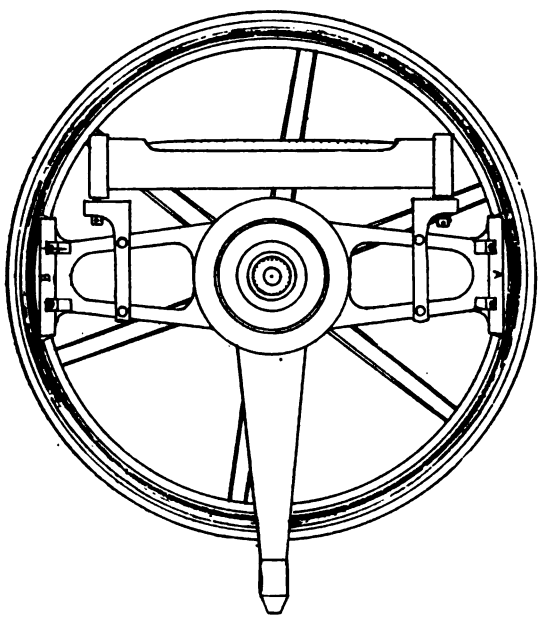
telescope—a method the value of which is evident, especially for hazy weather.

Light for illuminating the cross wires during night observations, is provided through the horizontal axis, which is made hollow for this purpose. A small elliptical silvered mirror, placed at the intersection of the axes of the trunnions and of the telescope, reflects the light upon the reticle. This mirror is mounted upon a short rod, which passes through a hole in the telescope tube, fitting tight enough to keep it in position, and is provided on the

FIG. 8.



outside with a milled head, by means of which the mirror may be turned to any desired angle. Dust is prevented from entering the telescope through the hole in the axis, by pieces of glass mounted in short hollow plugs, which are inserted in the ends of the axis. Light is supplied by a small brass lamp resting upon a bracket that is outrigged diagonally from the side of the wye block, where it is hung from two screws. A small mirror mounted on the end of a steel rod, serves to reflect the light into the hollow axis. The rod passes through a hole in the end of a pillar that projects from the front of the wye block, the end of the pillar being split, so that it holds the rod by friction.

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The vertical circle consists of a hub connected with a stiff half-inch rim, by six slender taper spokes. It is graduated to ten minutes on a silver ring set in the flat face of the rim, and reads to ten seconds by two opposite verniers. The circle is figured every ten degrees in quadrants, with the 90° points on a line parallel to the axis of the telescope. There is a similar difficulty in reading, due to the lack of distinction between the various subdivisions, that has been noticed when treating of the horizontal limb. The verniers are mounted on skeleton arms fixed to a hub, and have the usual ivory shades, lettered A and B. (Fig. 8.) A five-inch chambered level attached to the alidade arm, serves to show when the line joining the zero points of the two verniers is horizontal, in which position the mean of the readings of the verniers gives the zenith distance of the object to which the telescope is pointed. A lever arm is fixed solidly to the vernier hub; and brackets with opposing screws are attached to the inner sides of both standard uprights, to receive it. By moving these screws the level bubble may be brought to the centre of its run. This is rather troublesome to do, as the screws are coarse, and the level relatively delicate, in spite of its requiring a movement of seven seconds of arc to move the bubble over one division of its scale. The level tube is supplied with screws to adjust its height, and with others to rotate it about its axis.

The instrument is furnished with a chambered striding level, reading to six seconds for levelling the horizontal axis. It is also provided with a sun-shade for the telescope, a steel-pointed brass plumb bob, a reading-glass (which is not powerful enough to be of any use), a camel's-hair brush for removing dust from the lenses and graduated circle, a screw-driver, and a full set of adjusting pins.

The graduated portions of both circles, the verniers, pointer-end, and part of the micrometer heads are left bright; the handle is nickel-plated, and the rest of the instrument is japanned—part in a brass finish and part in a dark mottled green.

The theodolite is packed in two boxes. The telescope is taken out of the wyes and placed on blocks in the smaller box, where it is held in place by corresponding blocks in the cover. The rest of the instrument is placed on a thick plank that slides into the large box, and is wedged tight by blocks, while secure sockets are provided for all the separate pieces and the tools. All are so snug

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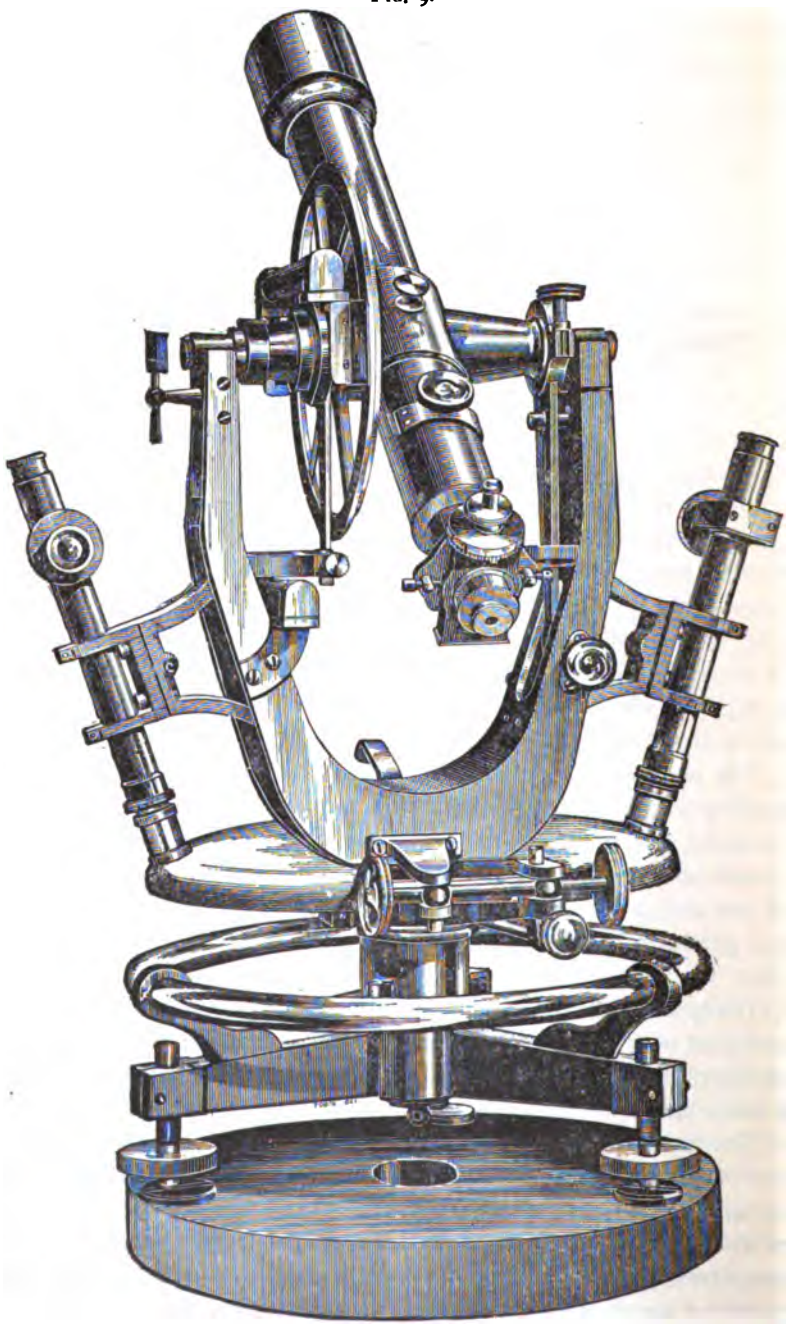
FIG. 9.



**Fauth Ten-inch Direction Instrument.**

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that no damage would be done by moderate jarring or by placing the boxes wrong-side up. To protect the instrument in travelling, the boxes are placed in strong padlocked packing-cases, with a layer of excelsior or other packing material around the inner box. The larger case is nearly two feet in cube, and weighs when packed a trifle over one hundred pounds.

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## METHODS OF MEASURING ANGLES BY ARCS AND BY SINGLE ANGLE.*

By C. G. MASSA, C. E.

THE theodolite having been placed in position over the station and carefully levelled and adjusted, we proceed to read the angles between the stations visible from this point. With a direction instrument this may be accomplished by either one of two methods:

1. The Method of Arcs or Directions.
2. The Method by Single Angle.

1. *The Method of Arcs or Directions.*—In this method the telescope is pointed at the various signals in succession, the reading of the limb being taken at each pointing, and the angles between the stations are obtained by subtracting the mean reading at each station from that at the next. If the stations observed lie entirely on one side of the observing station, that one on the extreme left is taken as an initial station; if not, the one that is the most distinctly visible in all weathers. So important has it been deemed by English geodesists to have the initial station clearly visible, that they have been in the habit of erecting a signal at a short distance from each observing station for this especial purpose; but this system has not been generally employed in this country, although it has been tried in some few instances where all the stations observed upon have been at long distances from the observing station.

The initial signal having been selected, the telescope is unclamped and moved until the pointer reads zero, when it is clamped. The capstan-head screws or other fastenings of the horizontal

* Memoir prepared for the Department of Geodesy.

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limb are loosened and the telescope and limb turned to the reference station, as good a bisection as possible being made, and the limb firmly clamped. Then the final bisection of the signal is made with the tangent screw, and the pointer and both of the microscopes are read and recorded, forward and backward micrometer readings being taken in order to correct for the error of run. The mean of the microscope readings gives the direction of the initial signal. After this has been done the telescope is unclamped and turned to the next signal, which is bisected, and the microscopes read as before, and this process is repeated for each station until the directions of all the signals have been read. After the readings of the micrometers on the last signal have been recorded the pointing is again examined, and if it proves satisfactory the same readings are recorded as the beginning of the return set; if not, a new pointing is made, and the micrometer readings taken and recorded. The telescope is now turned in the reverse direction, and readings on the various signals are taken as before, finishing with the initial signal. This reading should coincide very closely with that first obtained; if it does not, the set must be discarded and a new one taken. When the set forward and return has been finished, the telescope is reversed about its horizontal axis and a set forward and return taken as before. This, together with the direct set of observations, constitutes a series of readings, and the mean direction obtained in this way will be freed from the effect of residual errors of collimation and lack of horizontality of the transit axis, also from the effect of whatever slight eccentricity there may be in the limb. The order of procedure may be varied by continuing the forward set in each case and completing the horizon by reading on the initial station. This affords an additional condition (*i.e.*) that the last reading shall coincide with the first, and is the plan pursued by the U. S. Engineers in the latter part of the Lake Survey; but as the same result, except for the slight effect of twist in the vertical axis in the former case, is obtained by taking the reading on the initial station at the end of the return set, the completion of the horizon only serves in the case of a discrepancy to show whether the error occurred in the forward or return set. Now, as, if such a discrepancy does occur, the whole series has to be repeated, it would appear that very little practical advantage is gained by taking this extra reading. The result obtained as the mean of a single series, although free from the effects

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of other errors, contains the full effect of errors of graduation; and in order to eliminate this, it is desirable to obtain readings on each station upon as many different parts of the limb as possible. This requires that a number of series of readings should be taken with a different pointer-reading on the initial station for each series. In this country it is the practice to take a prime number of series, eleven being a favorite number for the purpose, with the object of having no two microscope readings on the same station fall upon the same part of the graduation, no matter how many microscopes may be employed. The settings of the pointer are made at distances apart, equal to $\frac{360}{N}$, where $N$ represents the number of series to be taken. With this system, when the full number of series has been completed, the whole limb will have been passed over. The engineers in charge of the great India Survey accomplished this in a slightly different way. They took an even number of series, usually either forty or fifty. If we let $M$ = number of microscopes and $N$ = number of series, then the arc between the two settings of the pointer = $\frac{360}{NM}$. Thus, when all the sets were completed, each microscope had passed over the angular distance between itself and the next, and no microscope could fall twice on the same portion of the limb in pointing at the same signal. But this introduced a new source of error. For if we divide the angle between two microscopes by 40 or 50, especially in their instruments, which had a large number of microscopes, it gives only a very small angle through which to turn the limb at the beginning of each series, and this angle is not large enough to overcome the effect of slight irregularities in the axis of the plate and of the telescope. The projections of the one catch in the depressions of the other, and as the limb is not turned enough to entirely disengage them, a decided twist is produced. In order to overcome this difficulty it was customary, during the latter part of the Survey, to add to the angle obtained by the formula alone half the angle between two adjacent microscopes, in order to obtain the pointer settings. Each microscope thus passed over the entire limb at least once without having any two readings on the same point. This system gave very good results, but required different settings for instruments provided with different numbers of microscopes. On this survey, Colonel Waugh advocated the reading

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of three series with the same initial index pointing, in order that any error might at once be discovered and rectified as a coincidence of two out of three readings would prove them to be the correct ones. It was also discovered during this survey that with some instruments, especially those of inferior construction, a constant error was produced in a chain of triangles by always making the initial pointing on the left-hand stations. Although unable wholly to account for this effect, Colonel Waugh supposed it to be due to irregularities in the vertical axis.

Since by the method of directions the angle between two stations is obtained by taking the difference of their readings, a constant error will have very little effect on the final result; and in order that any slight error that occurs may be constant, it is desirable that the conditions, under which the pointings and readings belonging to one series are made, should be as nearly the same as possible. Hence the reading should be made rapidly and before flexure of the plate and changes of temperature have time to affect the adjustment of instrument; or the movement of the sun changes the phase of the signals sighted. The illumination on the portions of the limb beneath the microscopes should always fall directly from above or parallel to the direction of the divisions, and never from one side, for this gives prominence to the side of the cut opposite that from which the light comes, and may cause the former side to be bisected by the micrometer wires, instead of the centre of the graduation. This is to be particularly guarded against in cases where the graduations are deeply cut. The theodolite should, of course, be protected from the wind and the direct rays of the sun. If during the reading of a series of angles, any of the signals should become invisible and remain so for any considerable length of time, they must either be omitted from the series entirely or when they reappear, the series must be begun over again. For if any delay was made to wait for the signals to become visible, some of the conditions might change from those prevailing at the beginning of the series; greatly impairing the accuracy of the work.

This method of angle measuring enables us, where all the surrounding signals are visible at once, to obtain a series of readings on all the observed stations in a short time; and by taking a number of such series on different parts of the plate a very accurate determination of all the angles may be made,—if good instru-

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ments be employed. This avoids the accumulative effect of twist in the axis produced by the method of repetitions; and although the latter only requires one reading of the circle to be made for a number of repetitions of the angle, whatever error is made in this reading being divided by the number of repetitions, the method of directions only requires about half as many pointings as are necessary for reading the same number of angles repeated an equal number of times by the method of repetitions; and as in the former method there are likely to be the same number of positive and negative errors in reading, the final result is theoretically free from error.

2. *The Method by Single Angles.*—This method seems to have been employed on many of the earlier triangulations, especially those executed before the method of arcs had come into vogue. Dr. Bremiker mentions that the French observers measured each angle independently, including that one necessary to complete the horizon. The same plan was adopted by Muffling and other German geodesists, while Gauss measured by single angles in much the same manner that the New York State Survey has recently done. This method has not been used generally either on the United States coast, the English ordnance, the Indian or the Lake surveys; nearly all of their angles having been measured by directions. But there have been certain circumstances under which it was necessary to have recourse to this method.

*First.*—When but one angle was to be read from a station, in which case the methods of arcs and of single angles are practically identical; and

*Second.*—Where but a couple of stations were visible at the same time, all the others being obscured by bad light or haze. In the latter case observers often have to employ the single angle system in order to avoid wasting time while waiting for clearer weather. The process of measuring an angle by this method is much as follows, but may be varied somewhat at the discretion of the observer. The limb is set with the telescope pointing at the station and clamped, as when reading by arc. The micrometers are read and then the telescope turned to the other signal and the circle read again; the telescope is now turned back over the arc to the first station and the limb again read. This may be done several times with telescope direct and then an equal number of times with it reversed; or each angle may be read forwards with the



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telescope direct and then backwards with it reversed, or *vice versa.* In the New York State Survey, as many combinations of angles as possible are made; without, however, closing the horizon, which it would generally seem advisable to do, as it introduces another condition. Thus, if they had five stations to read upon, the angles would be arranged in the following way: 1–2, 1–3, 1–4, 1–5; 2–3, 2–4, 2–5; 3–4, 3–5; 4–5; or $\frac{N(N-1)}{2}$ angles, in this case ten, $N$. being the number of stations. A new setting of the limb is taken for each angle read, the settings being scattered on the circle, so that no part is read twice for the same station.

It is pretty generally conceded that, when at the observing station all the signals show out clearly and sharply, so complete sets of directions can be taken, the system of single angles causes loss of time, often taking nearly twice as long to obtain measurements of the same number of angles. But in actual practice it is very commonly the case that signals which are clear in the morning become obscure in the afternoon, while other stations which could scarcely be seen in the morning show out strongly by afternoon light; and again, sometimes for weeks together it is impossible to see all the signals at the same time, different stations being poor on different days.

Now in both these cases there is a chance to make a great saving in time by reading the angle between any two signals that happen to show well at any moment, and in the first case this also allows considerable lengthening of the hours of daily work. The length of time that it often takes to read a set of arcs, permits a chance of error due to change in the instrument itself and also, when mounted on a observing tower, to alteration in the position of the theodolite in azimuth from the actual twisting of the tower. This trouble increases with the height of the tower, and is called station twist. Both of these errors are eliminated by the quick work of reading a single angle. Another advantage lies in the facility with which the value of the work may be judged in the field, thereby occasionally saving the reoccupation of a station for rereading weak angles; but a very much stronger argument for the system is, that only two stations, or one station and a reference mark (if such a mark be employed) are needed for observing; thus enabling every angle to be read under the very best conditions for insuring the most accurate work. Frequently, as we have

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already seen, one or two stations have to be omitted from a series of directions on account of mist, poor light, or negligent heliotrophers causing a great deal of complication in the reduction of the results, which would have been avoided by reading each angle independently. A case is mentioned in the work of the United States Coast and Geodetic Survey where twenty series with numerous omissions were taken at the station "Helderberg" in New York, which took a skilled computer some four weeks to get into shape. These considerations have induced the New York State Survey to use this method largely in their work and those in charge recommended its use in the future, especially for primary work in their final report of the Triangulation, 1887; they also cite some German authors who are very strongly in favor of this single angle system. Helmert practically advises its use before any other; he says, "This method is the only one to be employed where the greatest degree of precision is desired," and he mentions besides, that it is the only way in which lateral refraction is eliminated or measurable.

Also, Wright, in his "Adjustment of Observations" is another advocate of single angles. It is evident, however, that for night-work many of the advantages of "single angle" over "arcs" disappear.

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## THE GLYCERINE AND ARTIFICIAL BUTTER INDUSTRY UNDER UNITED STATES PATENTS.

By EMIL STAREK.

### Glycerine.

Under the class of glycerides, or fats and fat oils, there are two industries which, of late years, have assumed enormous proportions, viz., the manufacture of glycerine and artificial butter.

Glycerine was accidentally discovered, in 1779, by Scheele, while preparing lead-plaster from olive oil and litharge, and to which he gave the name of "the sweet principle of fats." Its true nature, however, was not understood until after the researches of Chevreul, from 1812 to 1823, the results of which appear in his *Recherches sur les Corps Gras d'Origine Animale*, and Pelouze, the

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latter of whom determined its exact formula. From that time great impetus was given to the glycerine industry, and the arts with which it is directly associated, viz., manufacture of soap and candles.

Glycerine constitutes the base of most fats which, chemically, are the salts of glycerine and one or more of the fatty acids. It is in the decomposition of these "salts," by means of alkalies or metallic oxides, that the glycerine is set free, and the fatty acid and alkali or metallic oxide combine and form a soap. Accordingly, one of the first commercial methods introduced for the manufacture of this article was to saponify fatty acids by means of lime, and then distil off the glycerine by means of superheated steam. This process, however, necessitated the use of sulphuric or oxalic acid to neutralize any free alkali, and to decompose the resulting lime-soap for the recovery of the fatty acids.

No early American patent appears to have been issued for such a process, but lime is used as an adjunct in the decomposition of fats by superheated steam in the patent to Werk, No. 21,711, Oct. 5, 1858; and later, especially under patents granted to Victor Litzelman, No. 267,753, Nov. 21, 1882; Max Ams and Victor Litzelman, No. 272,510, Feb. 20, 1883, and E. O. Baujard, No. 280,894, July 10, 1883, oxide of zinc and zinc, oxide of tin and chloride of lime, and a mixture of zinc oxide and lime are used to effect saponification and separation of the fatty acids from the glycerine and water.

Commercially, however, glycerine is obtained on a large scale by the decomposition of fats through the agency of superheated steam, and from the sub-lye of the soap-maker. In 1854, under patent No. 11,766, Oct. 3, 1854, R. A. Tilghman, of Philadelphia, subjected "fatty or oily bodies to the action of water at a high temperature and pressure, so as to cause the elements of those bodies to combine with water, and thereby obtain, at the same time, free fat acids and solution of glycerine."

His original apparatus is illustrated in the following cut, accompanied by a portion of the original description:

Fig. 1, of the said drawing, is a vertical section of this apparatus, and Fig. 2 shows the various parts of the apparatus in horizontal section.

Similar parts, in these figures, are marked with similar letters of reference.

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The fat or oil, in a fluid state, is placed in the vessel *a*, with from one-third to one-half its bulk of warm water. The disk or piston *b*, perforated with numerous small holes, being kept in rapid motion up and down in the vessel *a*, causes the fat or oil and water to

*Fig. 1.*

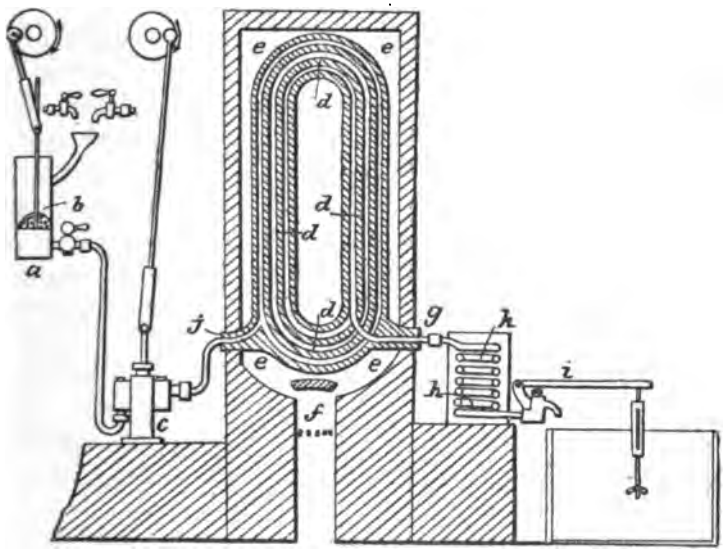
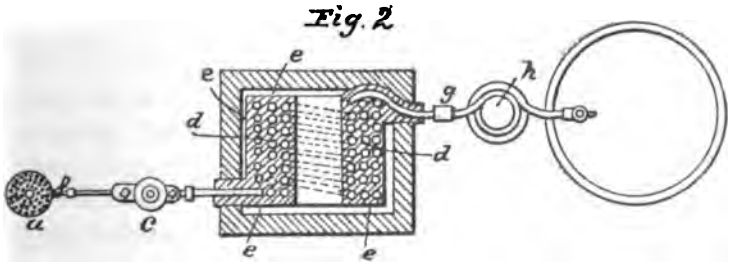



*Fig. 2*




form an emulsion or intimate mechanical mixture. A force-pump *c*, like those in common use for hydraulic presses, then drives the mixture through a long coil of very strong iron tube *d d d d*, which, being placed in the furnace *e e*, is heated by a fire *f* to about the temperature of melting lead.

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From the exit end *g*, of the heating tubes *d d*, the mixture, which has then become converted into free fat acids and solution of glycerine, passes on through another coiled iron tube, *h h h*, immersed in water, by which it is cooled down from its high temperature to below 212° Fahrenheit, after which it makes its escape through the exit valve *i* into the receiving vessel.

The iron tubes employed, and found to be convenient for this purpose, are about one-inch external diameter and about half-an-inch internal diameter, being such as are in common use for Perkins's hot-water apparatus. The ends of the tubes are joined together by welding to make the requisite length; but, when welding is not practicable, there may be substituted the kind of joints used for Perkins's hot-water apparatus, which are now well known. The heating-tube, *d d d*, is coiled several times backward and forward, so as to arrange a considerable length of tube in a moderate space. The different coils of the tube are kept about a quarter of an inch apart from each other, and the interval between is filled up solid with cast-iron, which also covers the outer coils or rows of tubes to the thickness of half or three-quarters of an inch, as shown in Fig. 2. This casing of metal insures a considerable uniformity of temperature in the different parts of the coil, adding also to its strength, and protecting it from injury by the fire.

The exit-valve *i* is so loaded that when the heating-tubes *d d d* are at the desired working temperature, and the pump *c* is not in action, it will not be opened by the internal pressure produced by the application of heat to the mixture, and therefore when the pump *c* is not in action, nothing escapes from the valve *i* if the temperature be not too high; but, when the pump forces fresh mixture into one end, *j*, of the heating-tubes *d d d*, the exit-valve *i* is thereby forced open to allow an equal amount of the mixture which has been operated upon to escape out of the cooling-tubes *h h* at the other end of the apparatus. No steam or air should be allowed to accumulate in the tubes, which should be kept entirely full of the mixture by properly increasing the speed of the machinery to make the current in the tubes sufficiently rapid to carry out any air remaining in the tubes.

In 1859, Wright & Fouché, patent No. 22,765, Jan. 25, 1859, constructed an apparatus whereby "a continuous automatic circulation of highly-heated water, in a very finely divided state, through the bodies under treatment" effected the decomposition described

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by Tilghman. Since then, apparatus has been devised whereby the fats are subjected to thorough agitation during the action of the steam, and are, also, thoroughly atomized while undergoing decomposition. In this connection, attention is particularly called to patents to F. Sahlfeld, No. 201,704, March 26, 1878; A. Kuehne, No. 215,372, May 13, 1879, and Benjamin T. Babbitt, No. 275,976, April 17, 1883, and No. 316,104, April 21, 1885.

Of late years, attempts have been made to recover glycerine from soap-makers' lye or sub-lve.

Among the first patents granted for the treatment of sub-lye for the recovery of glycerine is that to Benjamin T. Babbitt, No. 107,-324, September 13, 1870, which is described in another connection in this report.

C. V. Clolus, under patent No. 242,272, May 31, 1883, recovers the glycerine from soap lyes by treating the same with hydrochloric acid to the point of neutralization, which decomposes any fatty bodies, liberating the fatty acids, which are removed. The clear neutral liquor is evaporated to about 32° Baumè; at this point any precipitated salt is removed, and the glycerine extracted by centrifugal action. The liquor is treated by blowing air through the same, which removes the last traces of water, and as salt is relatively less soluble in anhydrous glycerine, most of the salt crystallizes out. As a final result of the evaporation, there remains a highly concentrated glycerine mixed with crystals of salt, which subjected to centrifugal action, separates the glycerine; this product, however, is immediately contaminated with fatty matter, and is not so pure as that treated by later processes.

J. P. Battershall, No. 251,992, January 3, 1882, neutralizes the alkalies of the soap liquor by sulphuric acid, or adds an excess in case it contains resin or fat, which latter is subsequently removed by straining; the liquor is then boiled and concentrated to about one-tenth of its original volume, which in cooling assumes the consistency of syrup or paste. This paste is then treated in a centrifugal machine, and the crude glycerine is thus separated.

Among the first patents which set forth an economic and rational treatment of this by-product, is that granted to A. Domeier and O. C. Hagemann, of London, No. 371,127, October 4, 1887. By the process therein set forth the soapy matters are precipitated in the form of insoluble soaps, the lye subsequently concentrated by boiling, and the further remaining fatty and resinous constituents

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are finally decomposed by means of hydrochloric acid, and removed mechanically with clay or alumina. Any remaining albuminous matters are removed by heating in the presence of soda, and the crude glycerine resulting from these operations may be distilled and refined in the ordinary way. In some cases where resin soap is manufactured simultaneously with glycerine, a quantity of resin is added to the lye after the lime has settled, the alkali in the lye combining with the resin forming a soap which is subsequently removed. This step is covered by patent to the same parties, No. 385,105, June 26, 1888. In the patent to E K. Mitting, No. 385,367, July 3, 1888, the fatty and resinous impurities are removed by combining with a precipitate of barium or strontium formed directly in the liquor by the addition of a soluble chloride of these metals, and subsequent addition of sulphuric acid. The salt which is recovered from the spent lyes is purified by a series of washings which remove therefrom the crude glycerine occluded by the salt in the process of crystallization. However, the latest attempts have been directed toward preventing this mechanical occlusion and adherence of glycerine, which must be removed in the final stage of the operation. For this purpose, apparatus has been devised whereby an undue accumulation of the salt crystals in the presence of the lye undergoing ebullition is avoided, and the occlusion above referred to is prevented. This result is accomplished by freeing the boiling portion of the glycerine liquor from the mineral precipitates as fast as they are formed by removing them to another and quiescent portion of the liquor, both portions being separable at need, thereby temporarily cutting off the boiling liquor from the precipitates. This apparatus and process covered by it are described in patent to A. Domeier and A. C. Hagemann, No. 428,468, May 20, 1890. The following sectional view, together with the description attached, will illustrate the principle covered by said patent:

A is the boiler or vessel in which the concentration is effected, B the inclosing brick-work or fire-clay, and C the fire-space.

D are metal plates forming the outer walls of the apparatus.

E and F are respectively girders and columns to carry the apparatus.

G is the part into which the precipitated salts fall as formed, and which can be separated from A by the closing of the valve H by means of the hand-wheel I.

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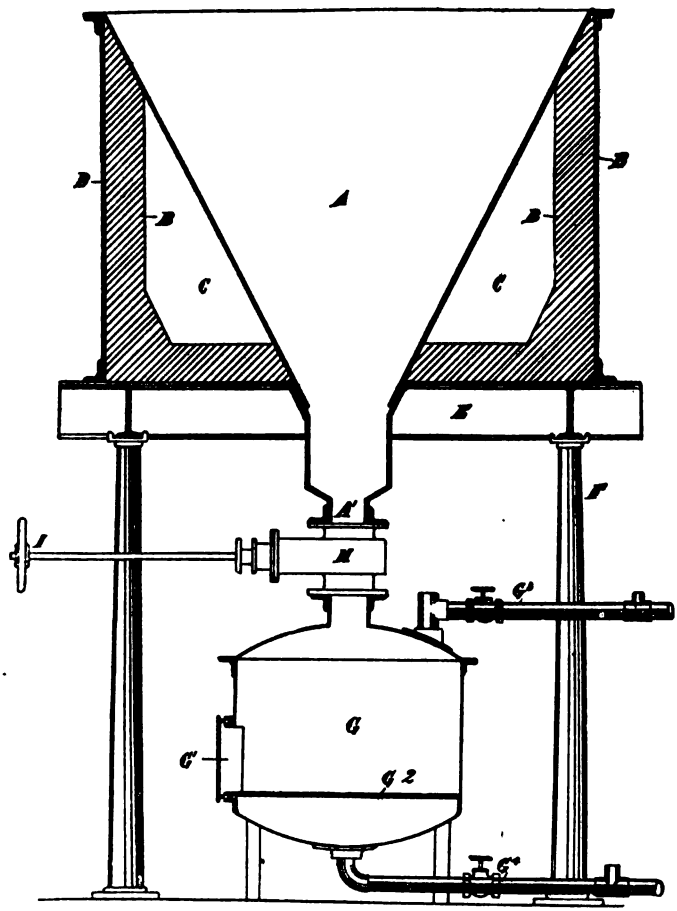
$G^1$ is a door through which the collected matter in G can be removed, and $G^2$ a strainer or perforated plate.

$G^3$ is a pipe through which soap-lye or brine containing less

FIG. 3.




glycerine than the liquor adhering to the mineral crystals, or pure brine, can be admitted for the purpose of washing the crystals of the mineral deposits free from the glycerine liquor adhering to them, the deposits remaining upon the perforated plate or filter $G^2$, and the liquor passing through the perforated plate or filter and escaping by the pipe $G^4$, from which it may be collected for re-use in any convenient manner.

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At the commencement of the operation the vessel A is filled with the soap-lye, which fills also the receptacle G, the communication between A and G being open, the pipes $G^3$ and $G^4$ being closed by suitable stop-cocks or equivalent devices. Then as the glycerine-liquor becomes more concentrated, the precipitates as formed, instead of accumulating in the boiling liquor, pass into the receptacle G, it being remembered that the liquor in A is boiling while the liquor in G is quiescent, the crystals being thus removed immediately as formed from contact with the boiling liquor. The fresh glycerine-liquor which it is from time to time necessary to feed into the apparatus may be supplied from below through the pipe $G^4$ into the quiescent portion, where most of it displaces the old liquor by pushing it into the boiling portion, and is itself only very gradually intermixed with the stronger liquor. As soon as the receptacle G is filled, or so far filled as may be desirable, with the deposited crystals the valve H is closed and the cocks $G^3$ and $G^4$ are opened, and after removing any excess of liquor through $G^4$ the washing is effected by passing the washing-liquor through the crystals by way of the cock $G^3$ and removing it through $G^4$. As soon as this washing is finished the valves $G^3$ and $G^4$ are closed, the door $G^1$ opened, and the crystals freed from glycerine removed from G, and the door $G^1$ again closed. The valve H can now be again opened and the process conducted as before, or the receptacle G may first be filled with another charge of the liquor to be evaporated previous to opening the valve H, the air in chamber G escaping during this operation by the vent *g*.

Some manufacturers have avoided the use of salt altogether by precipitating soap from soap-stock by the addition of an excess of alkali, which excess remains in solution. It can be removed by absorption, by treating with more tallow or fat, as described by the patent to B. T. Babbitt, No. 107,324, September 13, 1870. E. D. Mellen, however, under patent No. 422,140, February 25, 1890, separates this excess of alkali by saturating the solution of glycerine and alkali by carbonic acid, converting the alkali into a bicarbonate, in which form it is insoluble in glycerine. The glycerine may then be further purified.

Where milk of lime or hydrated caustic lime has been used to precipitate insoluble soaps from the sub-lye, the conversion of this precipitate into the hydrated oxide and the recovery of the fatty acid combined therewith is effected, as described by E. K. Mitting,

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No. 428,566, May 20, 1890, by treating the precipitate with acid, such as hydrochloric, which results in a soluble chloride of the metal, and a free fatty acid which is removed and purified. The soluble chloride is treated with an alkali-caustic soda, which precipitates the hydroxide of the original metal, and the salt produced by the union of the acid and alkali and which finds its way into the spent lye is recovered in the subsequent evaporation.

Besides hydrated lime, the hydrate of iron has been used which has the property of precipitating the insoluble soaps in a very basic form. A late patent covering this feature is that of Domeier & Hagemann, No. 453,829, June 9, 1891. In this case any free alkali is first neutralized, the hydrated iron oxide is then added which decomposes the soapy matters, and the alkali set free by the decomposition is further neutralized by suitable acid, and the resulting salt recovered in the subsequent concentration; the metallic soaps settle and are removed, while the crude glycerine is distilled.

The following are some of the more important American patents showing the development of the glycerine industry as outlined above:

| | |
|---|---|
| R. A. Tilghman, | No. 11,766, Oct. 3, 1854. |
| M. Werk, | No. 21,711, Oct. 5, 1858. |
| Wright & Fouché, | No. 22,765, Jan 25, 1859. |
| B. T. Babbitt, | No. 107,324, Sept. 13, 1870. |
| F. Sahlfeld, | No. 201,704, March 26, 1878. |
| A. Keuhne, | No. 215,372, May 13, 1879. |
| C. V. Clolus, | No. 242,272, May 31, 1881. |
| J. P. Battershall, | No. 251,992, Jan. 3, 1882. |
| V. Litzelmann, | No. 267,753, Nov. 21, 1882. |
| Max Ams & V. Litzelmann, | No. 272,510, Feb. 20, 1883. |
| B. T. Babbitt, | No. 275,976, April 17, 1883. |
| E. O. Baujard, | No. 280,894, July 10, 1883. |
| B. T. Babbitt, | No. 316,104, April 21, 1885. |
| Domeier & Hagemann, | No. 371,127, Oct. 4, 1887. |
| Domeier & Hagemann, | No. 385,105, June 26, 1888. |
| E. K. Mitting, | No. 385,367, July 3, 1888. |
| E. D. Mellen, | No. 422,140, Feb. 25, 1890. |
| Domeier & Hagemann, | No. 428,468, May 20, 1890. |
| E. K. Mitting, | No. 428,566, May 20, 1890. |
| Domeier & Hagemann, | No. 453,829, June 9, 1891. |

## Artificial Butter.

Mége Mouriéz while investigating the subject of milk and its productions noticed that cows which had been deprived of food

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continued to give milk, which milk continued to yield butter. He inferred from this that the fat of the milk was changed to butter. In 1869 he instituted a series of investigations at the suggestion of the late Emperor Napoleon III., to make a substitute for ordinary butter from the fat of animals. He succeeded in making an excellent substitute, by extracting the oleine from fat and churning this with milk and water, to which annatto was added for color; the mass was subsequently salted and the resulting product constituted a palatable butter substitute.

Nothing prior to the patent to M. Mége, 146,012, December 30, 1873, was patented in this country which could properly be termed "artificial butter," that is, where natural fat was subjected artificially to processes analogous to those which it undergoes in the elaboration of the cow's fat through her cellular and mammary tissues, and at the necessary temperature. Common butter had been compounded with foreign materials like the yolk of eggs and fresh milk to improve it, and a patent to this effect was issued to Mrs. D. H. McGregory, No. 68,639, September 10, 1867, but this although amounting to an artificial product did not constitute "artificial butter." Other artificial products, prior to the Mége patent are described by H. W. Bradley, No. 110,626, January 3, 1871, and A. Paraf, No. 137,564, April 8, 1873. The Bradley product was merely a mixture of beef or mutton suet, vegetable or fixed oils, and hog's lard, and was simply an attempt to make a suitable substitute for lard from the grosser fats. The Paraf patent was a step in the direction taken by Mége, but did not go beyond a mere separation of the oleomargarine from the stearine and membrane of the fat, although based on the physiologic principle, that the nutritive property of animal fat is confined mostly to the oleomargarine, the stearine being oxidized by pulmonary respiration.

The Mége process may be divided into four distinct steps. (1) Crushing, grinding or disintegrating the fat by any suitable machinery and washing the same by a stream of water which separates all soluble matter. (2) The separation and removal of the membrane and foreign material by gastric juice, produced from the half of the sheep's stomach treated with three litres of water containing thirty grammes of bisulphate of lime. This step should be conducted at a temperature of about 125° Fahr. (3) The purified fat is packed in sacks of woolen or cotton cloth and subjected to pressure or to centrifugal action. The oleomargarine separates

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from the stearine, but the temperature must be kept to about 80° Fahr., to allow the oleomargarine to flow freely. (4) Churning the oleomargarine with a small quantity of curds of milk or pure milk, and adding common salt and suitable coloring matter, *e.g.*, annatto. Butter made by this process contains about 86 per cent. of fat, 1 per cent. of casein and ash, and 13 per cent. of water, comparing favorably with ordinary market butter which contains 86 per cent. of fat, ½ per cent. of casein, $\frac{1}{10}$ per cent. of ash, and 14 per cent. of water.

In 1874, W. E. Andrew, patent No. 153,999, August 11, 1874, effected a separation of the oleomargarine by subjecting the fat to pressure, at a temperature sufficient to effect such separation, and allowing the oily product to run off to a cool place as fast as expressed, and without the use of water. John Hobbs, patent No. 154,251, August 18, 1874, avoided the use of alkalies used in the Mége process, by mixing molten tallow freed from animal tissue, with churned cream, allowing this to granulate, and finally whipping the same until it assumes a frothy appearance.

G. Cosine, patent No. 173,591, Fepruary 15, 1876, makes a mixture of animal oleine, olive, peanut or almond oil, lactic acid, and lappered cream or milk.

Dr. O. Boysen, patent No. 236,483, January 11, 1881, adds butyric acid to oleomargarine partially saponified by bicarbonate of soda; and W. H. Burnett, patent No. 266,580, October 24, 1882, makes an intimate mixture of lard, beef-suet, butter, glycerine salt, water, and coloring matter.

It will be observed that all the patents granted since the patent to Mége, contemplate the incorporation in one way or another, of the butter principle of cream or milk with one or all the constituents of animal fat.

To recapitulate: The leading United States patents which disclose the progress of the artificial butter industry are:

| | |
|---|---|
| A. Paraf, | No. 137,564, April 8, 1873. |
| H. Mége, | No. 146,012, Dec. 30, 1873. |
| " " Reissue, | No. 5868, May 12, 1874. |
| W. E. Andrew, | No. 153,999, Aug. 11, 1874. |
| John Hobbs, | No. 154,251, Aug. 18, 1874. |
| G. Cosine, | No. 173,591, Feb. 15, 1876. |
| H. Mége, Reissue, | No. 8424, Sept. 24, 1878. |
| Dr. O. Boysen, | No. 236,483, Jan. 11, 1881. |
| H. Mège, Reissue, | No. 10,137, June 13, 1882. |
| W. H. Burnett, | No. 266,580, Oct. 24, 1882. |

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# PRELIMINARY NOTICE OF THE REDUCTION OF RUTHERFURD'S STAR-PLATES.

By JOHN K. REES.

(Read at Meeting of National Academy of Sciences, November 12, 1891, New York City.)

Over thirty years ago, Lewis M. Rutherfurd began in this city his experiments in astronomical photography. He continued his work for twenty years. No photographs were taken after the year 1877.

Previous to 1868, Mr. Rutherfurd had experimented with various telescopes, both refracting and reflecting. His best photographs, up to that time, were taken with a refracting equatorial, corrected for chemical rays of light. This telescope was 11¼ inches in aperture, and had two object-glasses, one for seeing and the other for photographing. The seeing lens was unscrewed from the tube and the photographing lens was put into its place when photographs were to be taken. This telescope was sold to Dr. Gould, for use at Cordoba, in the Argentine republic. The object-glass was broken in transit. It was put together, and some photographs were taken with the broken lens; but afterwards, Dr. Gould had another lens made, with which he obtained many plates of the southern clusters.

Mr. Rutherfurd devised and constructed his own measuring machine for measuring the star-plates. This was arranged to measure position-angle and distance of every star on a plate from a central star. The distance-measures depended (up to 1872) entirely on readings of a micrometer-screw. With this machine, Mr. Rutherfurd had measures made on many of the star-plates, among them the Pleiades and Præsepe clusters. These measures were reduced by Dr. Gould, who presented his results to the National Academy in papers read in August, 1865 (on the Pleiades), and in April, 1870 (on the Præsepe group). In these reductions, Dr. Gould showed the great accuracy of the measures, and hence the immense value of the method for determining parallax and relative proper motions. Owing to circumstances, not necessary to detail here, these papers were not published until 1889,

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when they appeared in Vol. IV. of the *Memoirs* of the National Academy of Sciences.

After 1868, Mr. Rutherfurd finished a new form of photographing telescope. He wished to be able to use his telescope for seeing or for photographing without being compelled to take out the seeing object-glass. He therefore constructed a third lens which, being placed outside the ordinary object-glass, converted the telescope into a photographing instrument. The aperture of the telescope was 13 inches. Its visual focus was 15 feet 2 inches, and its photographic focus was 13 feet. In his work he took account of the effect of temperature on the length of the galvanized iron tube.

This telescope, with most of the instruments in his observatory, he gave to the Columbia College Observatory, in December, 1883. It is now mounted in the college observatory, 110 feet above ground, and, unfortunately, within 250 feet of one of the greatest railroads in the United States.

After 1868, all the photographs were taken with this improved instrument. Mr. Rutherfurd also improved his measuring machine by using a *glass scale*, one division being equal to ten revolutions of the micrometer screw. Thus, he used the screw only for a few revolutions. He also graduated a circle on glass, which, however, he did not employ in making measurements.

The new machine was used in making all measures after 1872. This machine was also presented to Columbia College in 1883, For a number of years thereafter it was loaned to Dr. Gould, who used it in measuring at Cambridge, Mass., the plates taken in South America.

On November 13, 1890, Mr. Rutherfurd gave all his best negatives to Columbia College. This valuable collection of photographs of the sun, the moon, and the star-clusters, has been placed in a fire-proof vault by direction of President Low. A complete list of these negatives has been prepared, and the New York Academy of Sciences has published the catalogue in its *Annals*, vol. vi., June, 1891. This catalogue shows:

| | | | |
|---|---|---|---|
| 175 | plates of the Sun, taken between | . . . . | 1860-1874. |
| 174 | " Solar spectrum, taken between | . . | 1860-1874. |
| 435 | " Moon, taken between . . . . | | 1858-1877. |
| 654 | " Star-clusters, taken between . . . | | 1858-1877. |

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Some of the principal star-plates may be mentioned:

| | | | |
|---|---|---|---|
| 33 | plates of | 44 Bootis, taken between | 1868-1875. |
| 12 | " | B. A. C, 8083 (Cassiopeæ), taken between | 1873-1874. |
| 27 | " | $\eta$ Cassiopeæ, taken between | 1870-1873. |
| 58 | " | $\mu$ Cassiopeæ, taken between | 1868-1873. |
| 15 | " | $\beta$ Cygni, taken between | 1875-1876. |
| 24 | " | 21 Cygni, taken between | 1875-1876. |
| 22 | " | 61 Cygni, taken between | 1871-1876. |
| 19 | " | 71 Cygni, taken between | 1875-1876. |
| 27 | " | Perseus clusters, taken between | 1865-1874. |
| 54 | " | Pleiades, taken between | 1865-1874. |
| 23 | " | Præsepe, taken between | 1865-1877. |
| 23 | " | 1830 Groombridge, taken between | 1872-1874. |

When this collection of negatives was turned over to the Observatory of Columbia College, it was arranged with Mr. Rutherfurd to have the work of reduction of the measures of the star-plates pushed forward as rapidly as possible. At my suggestion, Mr. Harold Jacoby, of the Observatory, undertook the reduction of the Pleiades-plates taken with the 13-inch and measured with the improved machine.

These reductions are now almost completed, and seem to indicate an accuracy of measures comparable with the best recent heliometer work. This Observatory will publish, very soon, in the *Annals* of the New York Academy of Sciences, a complete account of these reductions, as well as a description of the instruments used and methods employed. Our desire is to go forward in these reductions until we have finished all the measures made by Mr. Rutherfurd with the improved machine. These measures fill some twenty folio volumes of about two hundred pages each. Then, when all the measures are reduced, we may be able to measure the many negatives that remain unmeasured, and proceed to their reduction.

The members of the National Academy of Sciences thus are made aware that the college in which Mr. Rutherfurd was, for twenty-six years, an honored and most efficient trustee, is determined to put into useful and permanent shape the star-work of their eminent colleague, who did so much to originate means and methods, and gave most invaluable direction and impulse to astronomical photography.

Columbia College Observatory, November, 1891.

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REMARKS BY DR. B. A. GOULD.

It affords me especial pleasure to know that these long kept measurements of the earliest photographs available for astronomical determinations are now to be made available for scientific use. This college, which Mr. Rutherfurd held in such affection, and to which he has presented all his astronomical appliances—unsurpassed in themselves and now endowed with exceptional historic value—is the fittest place for the computations to be carried out; and I am confident that the work will be well done under the direction and guidance of Prof. Rees and his assistant Mr. Jacoby.

Mr. Rutherfurd was the originator and the introducer of the photographic method of observation. To him is due the first idea and employment of an object-glass constructed for employing the chemical rays rather than the visual ones; as also, later, that of the "photographic corrector" for adapting an ordinary object-glass to its best use in securing sharp definition of the stars upon the sensitive plate. He personally planned the construction of the first instruments of each of these classes, prescribed the curves for the several surfaces of the lenses, and superintended the preparation of the object-glasses,—which were made, with Mr. Fitz's assistance, in his own house, by methods devised and made practical by himself alone. So too was it he who introduced the precautions by which the sensitive film was guarded against distortion; it was he who first devised and constructed micrometric apparatus for measuring the impressions upon the plates; and he who first put this apparatus into practical use in executing the measurements. The large and delicate micrometer-screws were made by him, or under his constant supervision, at his dwelling house in this city, and the measurements were effected in his study.

It was my fortune to know of his work in this field at a comparatively early day, and to be able to follow it closely with sympathy and admiration. Hence I cannot refrain from bearing my testimony to the essential part which he bore in introducing and establishing the photographic method of observation. For many years he labored at it, without the sympathy or encouraging faith of astronomers generally; and in 1865 he did me the honor of placing in my hands a large number of measurements, and giving me permission to study and compute them. They had been made in his house, with apparatus designed and in great degree con-



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structed by himself, from photographs which he had personally taken by the aid of the telescope which he had himself devised and which was also in his house.

At the session of this Academy at Northampton in August, 1866, I had the pleasure of presenting a memoir containing the results of computations, made from these data, for determining the relative positions of 31 stars in the Pleiades. On the same day Mr. Rutherfurd communicated orally to the Academy a detailed account of his experiments, difficulties, and successes, as well as of the methods which he had finally adopted. It was his expressed intention to put this communication into writing at once, for publication as one of our memoirs. And I naturally delayed the publication of my own communication until it could be preceded by that of which it was essentially a follower, and which described the mode of obtaining the data upon which my own subsidiary memoir depended. The only step which I took toward publication was by mentioning the investigation in a letter sent during the same month to the *Astronomische Nachrichten*. This contained the resultant distances and position-angles from *Alcyone* for the brightest ten stars of the group, and called attention to their close accordance with Bessel's earlier values, deduced from his observations with the Konigsberg heliometer.

All this I am glad to recall here and now, Mr. President, because, from various statements made at far more recent dates, and the comparative newness of the interest in photographic observation, now manifested by astronomers, one might easily be led to suppose that the method had been recently introduced, or indeed hardly existed prior to the immense facilities afforded since 1880 by the dry-plate gelatine process. In this connection I may be excused from adding that the knowledge acquired from Mr. Rutherfurd of the important methods which he had developed had so aroused my enthusiasm for photographic observation, and my faith in its future application, that when I left this country for South America, in May 1870, I took with me the photographic object-glass with which his results had been obtained. The corrector for his new 13-inch telescope was then essentially completed; so that he kindly consented to part with its smaller predecessor.

The continued and disheartening obstacles which I encountered in the endeavor to secure photographic impressions of the clusters in the southern sky are known to many of the gentlemen present.

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Still, at the close of the year 1876 I had obtained nearly 500 satisfactory plates, and in November, 1882, there were 1100. A large part of these have already been measured, and the Argentine Government has now, in spite of its financial embarrassment, assigned me the means for resuming the computation.

Unless I am mistaken, all of the plates of which Prof. Rees has spoken were made some years before the discovery of the dry plate process. Indeed, by far the greater number of the impressions must have been taken previous to 1875. In later years the gelatine process has wonderfully facilitated the prosecution of stellar photography, making the duration of the necessary exposure very much less, while the limit of magnitude of the stars photographed is lowered to an almost incredible extent. And—since there is now practically no limit to the time of exposure, which may extend over all the hours of darkness for many successive nights, whereas it was previously restricted by the rapid drying of the plate—the positions of stars which are beyond the reach of powerful telescopes may be fixed at present by photographic methods. It is easy, to-day, to secure good impressions of ten or twenty times the number of stars during an exposure of given length; and easy to extend the time of exposure to fifty times that which was possible by the photographic processes known previous to 1880.

Still we must not forget that the simple reproduction upon the plate of an image of any part of the sky, is not astronomical research, but simply the attainment of a means for its convenient application. A photographic plate gives us no more than can be seen by any one using adequate visual appliances; and it is with the careful measurements of the plates that the astronomer's work begins. Here Mr. Rutherfurd's services have, as I have said, been as effective as in the collection of material; so that we owe to him not merely the first permanent records of the relative positions, at a given moment, of all the celestial objects impressed upon the sensitive plates, but the means and the accomplishment of the actual conversion of these records into accurate numerical data.

How greatly I rejoice at knowing that these numerical data, which have so long slumbered undisturbed, are now to be computed and given in due form to the astronomical world, it would be impossible to say.

Not long after the session of the Academy in August, 1865, to

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which I have referred, Mr. Rutherfurd was obliged, by impaired health, to leave home for a considerable period; and this, together with various duties which awaited his return, prevented him from writing out his memoir, which unhappily has never been published.

Meanwhile I computed the positions of more than thirty stars in the *Praesepe*, precisely in the same way as those of the *Pleiades*, yet retained the results in my own possession for the same reason.

When, however, it became necessary for me to leave home for South America, in May 1870, I communicated these positions to the Academy at its April session of that year. But I still withheld the manuscript of the two memoirs from the press, deeming it entirely improper that their publication should antedate Mr. Rutherfurd's description of the various methods by which he had obtained the fundamental data. And when I left home for an absence, which I supposed would not exceed three years, I handed the two manuscript articles to Mr. Rutherfurd himself, with an injunction that they should not be given to the Home Secretary for publication until his own memoir should accompany them.

For the whole period of my long absence the papers remained untouched; and, when they first saw the light, they were printed from the original manuscripts, without emendation and during my absence from the country, in the summer of 1888,—being twenty-two years after the identical manuscript of the first, and eighteen years after that of the second, had been presented to the Academy.

In the meanwhile various deficiencies in the method of computation, as well as one or two errors, had come to my knowledge. But for the sake of the history I preferred that these should remain, rather than that the memoirs should not be printed exactly as they had been originally prepared, and without correction. Of course I was unable even to revise the proofs, being in Europe at the time of their printing.

During this lapse of a score of years, improvements in the mode of computation and of the presentation of the results have naturally suggested themselves; and it is a welcome thought that under the direction of Prof. Rees, and his assistant, Mr. Jacoby, additional precautions and better methods will unquestionably be employed.

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# A CRYSTALLINE MAGMA OF INVERT-SUGAR.

By F. G. WIECHMANN, Ph.D.

INVERT-SUGAR is considered to be a combination of dextrose and levulose, in equal proportions.

$$\underset{\text{Dextrose.}}{C_6H_{12}O_6} + \underset{\text{Levulose.}}{C_6H_{12}O_6} = \underset{\text{Invert-sugar.}}{C_{12}H_{24}O_{12}}$$

It is well known, that aqueous solutions of invert-sugar suffer decomposition when exposed to light. From the liquid, originally of homogeneous composition there is deposited a white crystalline precipitate, commonly held to be dextrose, and above this there is generally found the remaining liquid.

The writer, while engaged in a study of the influence of light on solutions of invert-sugar, noticed, that the crystallization in one of the samples under observation, continued, until the solution of invert-sugar, which had originally been placed in the flask as a thick, colorless, transparent syrup, had become completely transformed into an almost solid, perfectly homogeneous, white, crystalline magma.

This specimen was carefully analyzed, and as the results may be of interest, they are here given in detail. Acknowledgment is due Mr. E. G. Brainerd for valuable assistance rendered in the securing of the analytical data.

*History of the Specimen.*—This solution was made by dissolving granulated sugar of the best quality, polarization 99.9–100.0, in distilled water, and inverting with strictly chemically pure HCl (specific gravity 1.20). The amount of acid used was 0.0265 per cent. of the weight of the sugar taken.

The solution was perfectly colorless and transparent; its density was about 80° Brix (43.11° Baumé), and on analysis it was found to contain 84.8 per cent. of invert-sugar on the dry substance. No attempt was made to neutralize the HCl, and the sample showed a slightly acid reaction.

This syrup was placed in a glass flask, which was well corked, and was exposed to diffused and to direct sun-light. The average temperature of the room in which the sample was kept was about 24° C.

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Decomposition of the invert-sugar commenced in the usual way, a crystalline deposit appearing at the bottom and on the sides of the flask. After three months time, the liquid had *entirely* disappeared, and in its place was found the snow-white crystalline magma.

*Gravimetric Analysis.*—The reducing-power of this magma on Fehling's solution (Soxhlet's formula) was determined by the method of E. Meissl.*

A solution of the magma was made up with distilled water. The specific gravity of this solution = 1.1427 at 15° C. This specific gravity = 32.7° Brix.;

$$100.00 \div 32.7 = 3.058.$$

Hence 3.058 grammes of this solution = 1.000 gramme on the dry substance.

Of this solution there were taken 39.827 grammes (= 13.024 grammes on the dry substance), and made up to 100 c.c. solution.

Of this solution 50 c.c. (= 6.512 grammes dry substance) were made up to 1000 c.c.

Of this solution, 1 c.c. = 0.006512. Used of this 35 c.c. = 0.2279 grammes of dry substance.

50 c.c. Fehling's solution (Soxhlet's formula) were taken and to this, when boiling, there were added the above 35 c.c. invert-sugar solution and 15 c.c. distilled water. Boiled for two minutes and then proceeded as usual in such determinations. This determination was made in all three times; the results follow:

| | Invert-sugar Magma. | Copper. |
|---|---|---|
| Determination 1, | 0.2279 reduced | 0.396 |
| " 2, | 0.2279 reduced | 0.392 |
| " 3, | 0.2279 reduced | 0.395 |
| | Average = | 0.394 |

According to the table calculated from the reducing factors determined by E. Meissl† 0.2278 gramme of pure invert-sugar reduce 0.4040 Cu. The amount of Cu reduced by 0.2279 gramme of the magma = 0.394 Cu, which amount of Cu corresponds to 0.2212 invert-sugar.‡

* *Zeitschrift des Vereins fur Rübenzucker-Industrie*, 1879, vol. 29, p. 1034.

† Wein E. *Tabellen zur Quantitativen Bestimmung der Zuckerarten*, p. 16.

‡ *Loc. cit.*

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The sample of magma therefore contains

$$0.2279 : 0.2212 :: 100 : x$$

$x = 97.06$.

Hence it contains 97.06 per cent. invert-sugar and

| | |
|---|---|
| | 100.00 |
| | 97.06 |
| | 2.94 |
| less $\frac{1}{20}$ | 0.14 |
| | 2.80 per cent. sucrose. |

*Optical Examination.*

*A. Determination of* $[a]_D^{20}$ *of Sample.*—Made a concentrated solution of the magma in distilled water. Specific gravity of this solution = 1.1427.

This is equal to 32.7 Brix.* 100.00 ÷ 32.7 = 3.058. This means that 3.058 grammes of this solution contain 1.0 gramme of dry substance.

Weighed off 30.58 grammes of this solution, equal to 10.000 grammes on the dry substance, and made this up to 100 c.c. at 17.5° C. with distilled water.

Placed this solution in a 200 m.m. tube and polarized in each instance at 20° C.

Polarization No. 1. Reading made 6 hours after preparation of solution = . . . . . — 10.7

Polarization No. 2. Reading made 27½ hours after preparation of solution = . . . . . — 10.6

Polarization No. 3. Reading made after heating the solution 15 minutes at 70° C. Reading taken 29¼ hours after original preparation of sample = . . . . — 10.5

Polarization No. 4. Reading made 53¼ hours after original preparation of sample = . . . . . — 10.5

*Calculation:*

$$-10.5 \times 0.346 = -3.6330°$$

$$[a]_D^{20} = \frac{-3.6330 \times 100}{10.0 \times 2} = -18.1650$$

* Wiechmann: *Sugar Analysis*, Table I.

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According to the formula given by Gubbe the value of pure invert-sugar in a 10 per cent. solution is

$$[a]_D^{20} = -20.0181.$$

If it may be assumed, that the sucrose present exerts the same effect on the plane of polarized light in the presence of this amount of invert-sugar, which it exercises when alone, then allowing for the dextro-rotation produced by the 2.8 per cent. of sucrose, = 1.8620, there would be obtained:

$$[a]_D^{20} = -20.027..$$

*B.* 26.048 grammes of the magma were dissolved up to 100 c.c. with distilled water. All polarizations were made at 20° C.

Polarization No. 1. Reading taken immmediately after making the solution = . . . . . — 7.9

Polarization No. 2. Taken 5 minutes after Polarization No. 1. = . . . . . — 9.0

Polarization No. 3. Taken 55 minutes after Polarization No. 1. = . . . . . — 18.0

Polarization No. 4. Taken 60 minutes after Polarization No. 1. = . . . . . — 18.2

Polarization No. 5. Taken 65 minutes after Polarization No. 1. = . . . . . — 18.3

Polarization No. 6. Taken 120 minutes after Polarization No. 1. = . . . . . — 21.4

Polarization No. 7. Taken 21 hours and 5 minutes after Polarization No. 1. = . . . . . — 23.3

Polarization No. 8. Taken 23 hours and 50 minutes after Polarization No. 1.= . . . . . — 23.3

*C.* 50 c.c. of above solution were taken immediately after making the same, 5 c.c. of HCl. (specific gravity 1.20) were added, and the solution heated for 5 minutes on a water-bath at 67° C. The solution was cooled, made up to 100 c.c. with distilled water and polarized.

All polarizations of this inverted solution were made at 20° C. All readings are recorded for full normal weight (26.048 grammes) and were made in a 200 m.m. tube.

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* Tollen's *Kurzes Handbuch der Kohlenhydrate*, p. 124.

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Polarization No. 1. Reading taken immediately after preparation of sample = . . . . . — 26.2

Polarization No. 2. Taken 60 minutes after Polarization No. 1. = . . . . . — 26.6

Polarization No. 3. Taken 18 hours and 40 minutes after Polarization No. 1. = . . . . . — 26.4

Polarization No. 4. Taken 20 hours and 30 minutes after Polarization No. 1. = . . . . . — 26.4

*Determination of the Specific Gravity of a* 10 *per cent.* (*on the dry substance*), *Solution.*—A solution of the magma was made with distilled water. The specific gravity of this solution = 1.1427 = 32.7° Brix.

$$100.00 \div 32.7 = 3.058,$$

therefore, 3.058 grammes of this solution = 1.000 gramme of dry substance. Of this solution there were weighed off 30.580 grammes = 10.000 grammes of dry substance. This was made up with distilled water to 100 c.c. at 17.5° C.

A careful determination showed the specific gravity of this solution to be = 1.03853. Herzfeld* states the specific gravity of a pure invert-sugar solution at 17.5° C. to be = 1.03901,

*Determination of the Melting Point of the Magma.*—5.000 grammes of the magma were taken, placed in a test-tube and slowly heated on a water-bath, which was started cold. A thermometer was inserted in the magma. At 50° C. the magma began to liquefy, the liquefaction commencing at the bottom; at 60.5° C. the liquefaction was completed. The time taken to warm from 50° to 60.5° C. was 29 minutes. The liquid sample was cooled and set aside in diffused daylight to see whether it would recrystallize.

For 12 days this sample showed no signs of crystallization, then two small crystals formed near the surface of the solution and the crystallization progressed slowly.

*Determination of Water in the Magma.*—Weighed off 2.000 grammes of magma. Placed in a vacuum over sulphuric acid and kept at a temperature of about 18° C.

In 645 hours the sample had lost 9.70 per cent. of water.

*Reaction of Magma.*—Tests made with methyl orange and Congo red show the magma to be slightly acid.

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* *Zeitschrift des Vereins für Rübenzucker Industrie*, 1887, vol. 37, p. 915.

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The composition of the magma, on the dry substance at the present time, is:

| | |
|---|---|
| Sucrose, . . . . . | 2.8 per cent. |
| Invert-sugar, . . . . . | 97.06 per cent. |

It seems most probable, that under existing conditions, the transformation of the remaining sucrose into invert-sugar, is only a question of time, and the specimen, exposed to full daylight, remains under observation.

Should this anticipated inversion of the sucrose be effected, an attempt will be made to separate all adhering fluid from the crystals, and these will be submitted to careful analysis in order to determine the proportions in which the dextrose and the levulose are present, and to learn whether possibly the specimen consists of pure invert-sugar in the crystalline condition.

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

By J. T. MONELL and C. R. MANN.

The following tables contain the usual factors for the reduction of meridian transit observations:

$$A = \frac{\sin(\varphi - \delta)}{\cos\delta},$$

$$B = \frac{\cos(\varphi - \delta)}{\cos\delta},$$

$$C = \frac{1}{\cos\delta}.$$

The values given in the tables have been computed with the latitude of Columbia College.

$$\varphi = 40^\circ\ 45'\ 23''.$$

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**TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.**

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| −22 0 | +0.959 | +0.494 | +1.079 | −12 0 | +0.814 | +0.619 | +1.022 |
| −21 40 | +0.954 | +0.498 | +1.076 | −11 40 | +0.809 | +0.623 | +1.021 |
| −21 20 | +0.949 | +0.503 | +1.074 | −11 20 | +0.805 | +0.627 | +1.020 |
| −21 0 | +0.944 | +0.507 | +1.071 | −11 0 | +0.800 | +0.631 | +1.019 |
| −20 40 | +0.939 | +0.511 | +1.069 | −10 40 | +0.796 | +0.635 | +1.018 |
| −20 20 | +0.934 | +0.516 | +1.066 | −10 20 | +0.791 | +0.638 | +1.017 |
| −20 0 | +0.929 | +0.520 | +1.064 | −10 0 | +0.786 | +0.642 | +1.015 |
| −19 40 | +0.924 | +0.524 | +1.062 | − 9 40 | +0.782 | +0.646 | +1.014 |
| −19 20 | +0.919 | +0.528 | +1.060 | − 9 20 | +0.777 | +0.650 | +1.013 |
| −19 0 | +0.914 | +0.533 | +1.058 | − 9 0 | +0.773 | +0.654 | +1.012 |
| −18 40 | +0.909 | +0.537 | +1.056 | − 8 40 | +0.768 | +0.658 | +1.012 |
| −18 20 | +0.904 | +0.541 | +1.054 | − 8 20 | +0.764 | +0.662 | +1.011 |
| −18 0 | +0.899 | +0.545 | +1.052 | − 8 0 | +0.759 | +0.666 | +1.010 |
| −17 40 | +0.894 | +0.550 | +1.050 | − 7 40 | +0.755 | +0.670 | +1.009 |
| −17 20 | +0.889 | +0.554 | +1.048 | − 7 20 | +0.750 | +0.673 | +1.008 |
| −17 0 | +0.884 | +0.558 | +1.046 | − 7 0 | +0.746 | +0.677 | +1.007 |
| −16 40 | +0.880 | +0.562 | +1.044 | − 6 40 | +0.741 | +0.681 | +1.007 |
| −16 20 | +0.875 | +0.566 | +1.042 | − 6 20 | +0.737 | +0.685 | +1.006 |
| −16 0 | +0.870 | +0.570 | +1.040 | − 6 0 | +0.732 | +0.689 | +1.005 |
| −15 40 | +0.865 | +0.574 | +1.039 | − 5 40 | +0.728 | +0.693 | +1.005 |
| −15 20 | +0.860 | +0.578 | +1.037 | − 5 20 | +0.724 | +0.697 | +1.004 |
| −15 0 | +0.856 | +0.583 | +1.035 | − 5 0 | +0.719 | +0.700 | +1.004 |
| −14 40 | +0.851 | +0.587 | +1.034 | − 4 40 | +0.715 | +0.704 | +1.003 |
| −14 20 | +0.846 | +0.591 | +1.032 | − 4 20 | +0.710 | +0.708 | +1.003 |
| −14 0 | +0.842 | +0.595 | +1.031 | − 4 0 | +0.706 | +0.712 | +1.003 |
| −13 40 | +0.837 | +0.599 | +1.029 | − 3 40 | +0.701 | +0.716 | +1.002 |
| −13 20 | +0.832 | +0.603 | +1.028 | − 3 20 | +0.697 | +0.719 | +1.002 |
| −13 0 | +0.828 | +0.607 | +1.026 | − 3 0 | +0.693 | +0.723 | +1.001 |
| −12 40 | +0.823 | +0.611 | +1.025 | − 2 40 | +0.688 | +0.727 | +1.001 |
| −12 20 | +0.818 | +0.615 | +1.023 | − 2 20 | +0.684 | +0.731 | +1.000 |
| −12 0 | +0.814 | +0.619 | +1.022 | − 2 0 | +0.679 | +0.735 | +1.000 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| — 2 0 | +0.679 | +0.735 | +1.000 | + 8 0 | +0.547 | +0.849 | +1.010 |
| — 1 40 | +0.675 | +0.738 | +1.000 | + 8 20 | +0.542 | +0.853 | +1.011 |
| — 1 20 | +0.671 | +0.742 | +1.000 | + 8 40 | +0.537 | +0.857 | +1.012 |
| — 1 0 | +0.666 | +0.746 | +1.000 | + 9 0 | +0.533 | +0.861 | +1.012 |
| — 0 40 | +0.662 | +0.750 | +1.000 | + 9 20 | +0.528 | +0.865 | +1.013 |
| — 0 20 | +0.657 | +0.754 | +1.000 | + 9 40 | +0.524 | +0.869 | +1.014 |
| 0 0 | +0.653 | +0.757 | +1.000 | +10 0 | +0.519 | +0.873 | +1.015 |
| + 0 20 | +0.648 | +0.761 | +1.000 | +10 20 | +0.515 | +0.877 | +1.017 |
| + 0 40 | +0.644 | +0.765 | +1.000 | +10 40 | +0.510 | +0.881 | +1.018 |
| + 1 0 | +0.640 | +0.769 | +1.000 | +11 0 | +0.506 | +0.884 | +1.019 |
| + 1 20 | +0.635 | +0.773 | +1.000 | +11 20 | +0.501 | +0.888 | +1.020 |
| + 1 40 | +0.631 | +0.776 | +1.000 | +11 40 | +0.496 | +0.892 | +1.021 |
| + 2 0 | +0.627 | +0.780 | +1.000 | +12 0 | +0.492 | +0.896 | +1.022 |
| + 2 20 | +0.622 | +0.784 | +1.000 | +12 20 | +0.487 | +0.900 | +1.023 |
| + 2 40 | +0.618 | +0.788 | +1.001 | +12 40 | +0.483 | +0.904 | +1.025 |
| + 3 0 | +0.613 | +0.792 | +1.001 | +13 0 | +0.478 | +0.908 | +1.026 |
| + 3 20 | +0.609 | +0.795 | +1.002 | +13 20 | +0.473 | +0 912 | +1.028 |
| + 3 40 | +0.604 | +0·799 | +1.002 | +13 40 | +0.469 | +0.916 | +1.029 |
| + 4 0 | +0.600 | +0.803 | +1.003 | +14 0 | +0.464 | +0.920 | +1.031 |
| + 4 20 | +0.595 | +0.807 | +1.003 | +14 20 | +0.459 | +0.924 | +1.032 |
| + 4 40 | +0.591 | +0.811 | +1.003 | +14 40 | +0.455 | +0.928 | +1.034 |
| + 5 0 | +0.587 | +0.815 | +1.004 | +15 0 | +0.450 | +0.932 | +1.035 |
| + 5 20 | +0.582 | +0.818 | +1.004 | +15 20 | +0.445 | +0.936 | +1.037 |
| + 5 40 | +0.578 | +0.822 | +1.005 | +15 40 | +0.440 | +0.941 | +1.039 |
| + 6 0 | +0.573 | +0.826 | +1.005 | +16 0 | +0.436 | +0.945 | +1.040 |
| + 6 20 | +0.569 | +0.830 | +1.006 | +16 20 | +0.431 | +0.949 | +1.042 |
| + 6 40 | +0.564 | +0.834 | +1.007 | +16 40 | +0.426 | +0.953 | +1.044 |
| + 7 0 | +0.560 | +0.838 | +1.007 | +17 0 | +0.421 | +0.957 | +1.046 |
| + 7 20 | +0.555 | +0.841 | +1.008 | +17 20 | +0.416 | +0.961 | +1.048 |
| + 7 40 | +0.551 | +0.846 | +1.009 | +17 40 | +0.412 | +0.965 | +1.050 |
| + 8 0 | +0.547 | +0.849 | +1.010 | +18 0 | +0.407 | +0.969 | +1.052 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| +18 0 | +0.407 | +0.969 | +1.052 | +28 0 | +0.250 | +1.105 | +1.133 |
| +18 20 | +0.402 | +0.974 | +1.054 | +28 20 | +0.241 | +1.110 | +1.136 |
| +18 40 | +0.397 | +0.978 | +1.056 | +28 40 | +0.239 | +1.114 | +1.139 |
| +19 0 | +0.392 | +0.982 | +1.058 | +29 0 | +0.233 | +1.119 | +1.143 |
| +19 20 | +0.387 | +0.987 | +1.060 | +29 20 | +0.227 | +1.124 | +1.147 |
| +19 40 | +0.382 | +0.991 | +1.062 | +29 40 | +0.221 | +1.129 | +1.151 |
| +20 0 | +0.377 | +0.995 | +1.064 | +30 0 | +0.215 | +1.135 | +1.155 |
| +20 20 | +0.372 | +0.999 | +1.066 | +30 10 | +0.213 | +1.137 | +1.157 |
| +20 40 | +0.367 | +1.003 | +1.069 | +30 20 | +0.210 | +1.140 | +1.159 |
| +21 0 | +0.362 | +1.008 | +1.071 | +30 30 | +0.207 | +1.142 | +1.161 |
| +21 20 | +0.357 | +1.012 | +1.074 | +30 40 | +0.204 | +1.145 | +1.163 |
| +21 40 | +0.352 | +1.017 | +1.076 | +30 50 | +0.201 | +1.147 | +1.165 |
| +22 0 | +0.347 | +1.021 | +1.079 | +31 0 | +0.198 | +1.150 | +1.167 |
| +22 20 | +0.342 | +1.026 | +1.081 | +31 10 | +0.195 | +1.152 | +1.169 |
| +22 40 | +0.336 | +1.030 | +1.084 | +31 20 | +0.192 | +1.155 | +1.171 |
| +23 0 | +0.331 | +1.035 | +1.086 | +31 30 | +0.189 | +1.158 | +1.173 |
| +23 20 | +0.326 | +1.039 | +1.089 | +31 40 | +0 186 | +1.160 | +1.175 |
| +23 40 | +0.321 | +1.044 | +1.092 | +31 50 | +0.182 | +1.163 | +1.177 |
| +24 0 | +0.316 | +1.048 | +1.095 | +32 0 | +0.180 | +1.165 | +1.179 |
| +24 20 | +0.310 | +1.053 | +1.097 | +32 10 | +0.176 | +1.168 | +1.181 |
| +24 40 | +0.305 | +1.057 | +1.100 | +32 20 | +0.173 | +1.171 | +1.184 |
| +25 0 | +0.300 | +1.062 | +1.103 | +32 30 | +c.170 | +1.173 | +1.186 |
| +25 20 | +0.294 | +1.067 | +1.106 | +32 40 | +0.167 | +1.176 | +1.188 |
| +25 40 | +0.289 | +1.071 | +1.109 | +32 50 | +0.164 | +1.179 | +1.190 |
| +26 0 | +0.284 | +1.076 | +1.113 | +33 0 | +0.161 | +1.182 | +1.192 |
| +26 20 | +0.278 | +1.081 | +1.116 | +33 10 | +0.158 | +1.184 | +1.195 |
| +26 40 | +0.272 | +1.085 | +1.119 | +33 20 | +0.155 | +1.187 | +1.197 |
| +27 0 | +0.267 | +1.090 | +1.122 | +33 30 | +0.152 | +1.190 | +1.199 |
| +27 20 | +0.261 | +1.095 | +1.126 | +33 40 | +0.148 | +1.192 | +1.202 |
| +27 40 | +0.256 | +1.100 | +1.129 | +33 50 | +0.145 | +1.195 | +1.204 |
| +28 0 | +0.250 | +1.105 | +1.133 | +34 0 | +0.142 | +1.198 | +1.206 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| +34 0 | +0.142 | +1.198 | +1.206 | +39 0 | +0.039 | +1.286 | +1.287 |
| +34 10 | +0.139 | +1.201 | +1.209 | +39 10 | +0.036 | +1.289 | +1.290 |
| +34 20 | +0.135 | +1.203 | +1.211 | +39 20 | +0.032 | +1.293 | +1.293 |
| +34 30 | +0.132 | +1.206 | +1.213 | +39 30 | +0.029 | +1.296 | +1.296 |
| +34 40 | +0.129 | +1.209 | +1.216 | +39 40 | +0.025 | +1.299 | +1.299 |
| +34 50 | +0.126 | +1.212 | +1.218 | +39 50 | +0.021 | +1.302 | +1.302 |
| +35 0 | +0.122 | +1.215 | +1.221 | +40 0 | +0.017 | +1.305 | +1.305 |
| +35 10 | +0.119 | +1.218 | +1.223 | +40 10 | +0.013 | +1.309 | +1.309 |
| +35 20 | +0.116 | +1.220 | +1.226 | +40 20 | +0.009 | +1.312 | +1.312 |
| +35 30 | +0.113 | +1.223 | +1.228 | +40 30 | +0.006 | +1.315 | +1.315 |
| +35 40 | +0.109 | +1.226 | +1.231 | +40 40 | +0.002 | +1.318 | +1.318 |
| +35 50 | +0.106 | +1.229 | +1.234 | +40 50 | −0.001 | +1.322 | +1.322 |
| +36 0 | +0.102 | +1.232 | +1.236 | +41 0 | −0.006 | +1.325 | +1.325 |
| +36 10 | +0.099 | +1.235 | +1.239 | +41 10 | −0.010 | +1.328 | +1.328 |
| +36 20 | +0.096 | +1.238 | +1.241 | +41 20 | −0.013 | +1.332 | +1.332 |
| +36 30 | +0.092 | +1.241 | +1.244 | +41 30 | −0.017 | +1.335 | +1.335 |
| +36 40 | +0.089 | +1.244 | +1.247 | +41 40 | −0.021 | +1.339 | +1.339 |
| +36 50 | +0.085 | +1.247 | +1.249 | +41 50 | −0.025 | +1.342 | +1.342 |
| +37 0 | +0.082 | +1.249 | +1.252 | +42 0 | −0.029 | +1.345 | +1.346 |
| +37 10 | +0.079 | +1.252 | +1.255 | +42 10 | −0.033 | +1.349 | +1.349 |
| +37 20 | +0.075 | +1.255 | +1.258 | +42 20 | −0.037 | +1.352 | +1.353 |
| +37 30 | +0.072 | +1.258 | +1.261 | +42 30 | −0.041 | +1.356 | +1.356 |
| +37 40 | +0.068 | +1.261 | +1.263 | +42 40 | −0.045 | +1.359 | +1.360 |
| +37 50 | +0.065 | +1.264 | +1.266 | +42 50 | −0.049 | +1.363 | +1.364 |
| +38 0 | +0.061 | +1.268 | +1.269 | +43 0 | −0.054 | +1.366 | +1.367 |
| +38 10 | +0.059 | +1.271 | +1.272 | +43 10 | −0.058 | +1.370 | +1.371 |
| +38 20 | +0.054 | +1.274 | +1.275 | +43 20 | −0.062 | +1.373 | +1.375 |
| +38 30 | +0.050 | +1.277 | +1.278 | +43 30 | −0.066 | +1.377 | +1.379 |
| +38 40 | +0.047 | +1.280 | +1.281 | +43 40 | −0.070 | +1.381 | +1.382 |
| +38 50 | +0.043 | +1.283 | +1.284 | +43 50 | −0.074 | +1.384 | +1.386 |
| +39 0 | +0.039 | +1.286 | +1.287 | +44 0 | −0.079 | +1.388 | +1.390 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| +44 0 | —0.079 | +1.388 | +1.390 | +49 0 | —0.219 | +1.509 | +1.524 |
| +44 10 | —0.083 | +1.392 | +1.394 | +49 10 | —0.224 | +1.513 | +1.529 |
| +44 20 | —0.087 | +1.395 | +1.398 | +49 20 | —0.229 | +1.517 | +1.535 |
| +44 30 | —0.092 | +1.399 | +1.402 | +49 30 | —0.234 | +1.522 | +1.540 |
| +44 40 | —0.096 | +1.403 | +1.406 | +49 40 | —0.239 | +1.526 | +1.545 |
| +44 50 | —0.100 | +1.407 | +1.410 | +49 50 | —0.245 | +1.531 | +1.550 |
| +45 0 | —0.105 | +1.410 | +1.414 | +50 0 | —0.250 | +1.536 | +1.556 |
| +45 10 | —0.109 | +1.414 | +1.418 | +50 10 | —0.255 | +1.540 | +1.561 |
| +45 20 | —0.114 | +1.418 | +1.423 | +50 20 | —0.261 | +1.545 | +1.567 |
| +45 30 | —0.118 | +1.422 | +1.427 | +50 30 | —0.266 | +1.549 | +1.572 |
| +45 40 | —0.123 | +1.426 | +1.431 | +50 40 | —0.272 | +1.554 | +1.578 |
| +45 50 | —0.127 | +1.430 | +1.435 | +50 50 | —0.277 | +1.559 | +1.583 |
| +46 0 | —0.132 | +1.434 | +1.440 | +51 0 | —0.283 | +1.564 | +1.589 |
| +46 10 | —0.136 | +1.438 | +1.444 | +51 10 | —0.288 | +1.569 | +1.595 |
| +46 20 | —0.141 | +1.442 | +1.448 | +51 20 | —0.294 | +1.573 | +1.601 |
| +46 30 | —0.145 | +1.446 | +1.453 | +51 30 | —0.299 | +1.578 | +1.606 |
| +46 40 | —0.150 | +1.450 | +1.457 | +51 40 | —0.305 | +1.583 | +1.612 |
| +46 50 | —0.155 | +1.454 | +1.462 | +51 50 | —0.311 | +1.588 | +1.618 |
| +47 0 | —0.159 | +1.458 | +1.466 | +52 0 | —0.317 | +1.593 | +1.624 |
| +47 10 | —0.164 | +1.462 | +1.471 | +52 10 | —0.322 | +1.598 | +1.630 |
| +47 20 | —0.169 | +1.466 | +1.476 | +52 20 | —0.328 | +1.603 | +1.637 |
| +47 30 | —0.174 | +1.470 | +1.480 | +52 30 | —0.334 | +1.608 | +1.643 |
| +47 40 | —0.179 | +1.474 | +1.485 | +52 40 | —0.340 | +1.613 | +1.649 |
| +47 50 | —0.183 | +1.478 | +1.490 | +52 50 | —0.346 | +1.619 | +1.655 |
| +48 0 | —0.188 | +1.483 | +1.494 | +53 0 | —0.353 | +1.624 | +1.662 |
| +48 10 | —0.193 | +1.487 | +1.499 | +53 10 | —0.358 | +1.629 | +1.668 |
| +48 20 | —0.198 | +1.491 | +1.504 | +53 20 | —0.364 | +1.634 | +1.675 |
| +48 30 | —0.203 | +1.495 | +1.509 | +53 30 | —0.371 | +1.640 | +1.681 |
| +48 40 | —0.208 | +1.500 | +1.514 | +53 40 | —0.377 | +1.645 | +1.688 |
| +48 50 | —0.213 | +1.504 | +1.519 | +53 50 | —0.383 | +1.651 | +1.695 |
| +49 0 | —0.219 | +1.509 | +1.524 | +54 0 | —0.390 | +1.656 | +1.701 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| +54 0 | —0.390 | +1.656 | +1.701 | +59 0 | —0.608 | +1.844 | +1.942 |
| +54 10 | —0.396 | +1.662 | +1.708 | +59 10 | —0.616 | +1.851 | +1.951 |
| +54 20 | —0.402 | +1.667 | +1.715 | +59 20 | —0.625 | +1.859 | +1.961 |
| +54 30 | —0.409 | +1.673 | +1.722 | +59 30 | —0.633 | +1.866 | +1.970 |
| +54 40 | —0.415 | +1.678 | +1.729 | +59 40 | —0.642 | +1.873 | +1.980 |
| +54 50 | —0.422 | +1.684 | +1.736 | +59 50 | —0.650 | +1.881 | +1.990 |
| +55 0 | —0.429 | +1.690 | +1.744 | +60 0 | —0.659 | +1.888 | +2 000 |
| +55 10 | —0.436 | +1.696 | +1.751 | +60 10 | —0.668 | +1.896 | +2.010 |
| +55 20 | —0.442 | +1.702 | +1.758 | +60 20 | —0.677 | +1.904 | +2.020 |
| +55 30 | —0.449 | +1.707 | +1.766 | +60 30 | —0.686 | +1.911 | +2.031 |
| +55 40 | —0.456 | +1.713 | +1.773 | +60 40 | —0.695 | +1.919 | +2.041 |
| +55 50 | —0.463 | +1.719 | +1.781 | +60 50 | —0.704 | +1.927 | +2.052 |
| +56 0 | —0.470 | +1.725 | +1.788 | +61 0 | —0.714 | +1.935 | +2.063 |
| +56 10 | —0.477 | +1.731 | +1.796 | +61 10 | —0.723 | +1.943 | +2.074 |
| +56 20 | —0.484 | +1.738 | +1.804 | +61 20 | —0.733 | +1.952 | +2.085 |
| +56 30 | —0.492 | +1.744 | +1.812 | +61 30 | —0.742 | +1.960 | +2.096 |
| +56 40 | —0.499 | +1.750 | +1.820 | +61 40 | —0.752 | +1.968 | +2.107 |
| +56 50 | —0.506 | +1.756 | +1.828 | +61 50 | —0.762 | +1.977 | +2.118 |
| +57 0 | —0.514 | +1.763 | +1.836 | +62 0 | —0.772 | +1.985 | +2.130 |
| +57 10 | —0.521 | +1.769 | +1.844 | +62 10 | —0.782 | +1.994 | +2.142 |
| +57 20 | —0.529 | +1.776 | +1.853 | +62 20 | —0.792 | +2.003 | +2.154 |
| +57 30 | —0.536 | +1.782 | +1.861 | +62 30 | —0.802 | +2.012 | +2.166 |
| +57 40 | —0.544 | +1.789 | +1.870 | +62 40 | —0.813 | +2.021 | +2.178 |
| +57 50 | —0.552 | +1.796 | +1.878 | +62 50 | —0.823 | +2.030 | +2.190 |
| +58 0 | —0.559 | +1.802 | +1.887 | +63 0 | —0.834 | +2.039 | +2.203 |
| +58 10 | —0.567 | +1.809 | +1.896 | +63 10 | —0.845 | +2.048 | +2.215 |
| +58 20 | —0.575 | +1.816 | +1.905 | +63 20 | —0.856 | +2.057 | +2.228 |
| +58 30 | —0.583 | +1.823 | +1.914 | +63 30 | —0.866 | +2.067 | +2.241 |
| +58 40 | —0.591 | +1.830 | +1.923 | +63 40 | —0.878 | +2.077 | +2.254 |
| +58 50 | —0.600 | +1.837 | +1.932 | +63 50 | —0.8 9 | +2.086 | +2.268 |
| +59 0 | —0.608 | +1.844 | +1.942 | +64 0 | —0.900 | +2.096 | +2.281 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| +64 0 | —0.900 | +2.096 | +2.281 | +69 0 | —1.321 | +2.458 | +2 790 |
| +64 10 | —0.912 | +2.106 | +2.295 | +69 10 | —1.338 | +2.473 | +2.812 |
| +64 20 | —0.923 | +2.116 | +2.309 | +69 20 | —1.355 | +2.488 | +2.833 |
| +64 30 | —0.935 | +2.126 | +2.323 | +69 30 | —1.373 | +2.504 | +2.855 |
| +64 40 | —0.947 | +2.137 | +2.337 | +69 40 | —1.391 | +2.519 | +2.878 |
| +64 50 | —0.959 | +2.147 | +2.352 | +69 50 | —1.410 | +2.535 | +2.901 |
| +65 0 | —0.972 | +2.158 | +2.366 | +70 0 | —1.428 | +2.551 | +2.924 |
| +65 10 | —0.984 | +2.168 | +2.381 | +70 5 | —1.438 | +2.559 | +2.936 |
| +65 20 | —0.997 | +2.179 | +2.396 | +70 10 | —1.447 | +2.567 | +2.947 |
| +65 30 | —1.009 | +2.190 | +2.411 | +70 15 | —1.457 | +2.576 | +2.959 |
| +65 40 | —1.022 | +2.201 | +2.427 | +70 20 | —1.467 | +2.584 | +2.971 |
| +65 50 | —1.035 | +2.212 | +2.443 | +70 25 | —1.476 | +2.593 | +2.983 |
| +66 0 | —1.049 | +2.224 | +2.459 | +70 30 | —1.486 | +2.601 | +2.996 |
| +66 10 | —1.062 | +2.235 | +2.475 | +70 35 | —1.496 | +2.610 | +3.008 |
| +66 20 | —1.067 | +2.247 | +2.491 | +70 40 | —1.506 | +2.618 | +3.021 |
| +66 30 | —1.089 | +2.259 | +2.508 | +70 45 | —1.516 | +2.627 | +3.033 |
| +66 40 | —1.103 | +2.271 | +2.525 | +70 50 | —1.527 | +2.636 | +3.046 |
| +66 50 | —1.117 | +2.283 | +2.542 | +70 55 | —1.537 | +2.645 | +3.059 |
| +67 0 | —1.132 | +2.296 | +2.559 | +71 0 | —1.547 | +2.654 | +3.072 |
| +67 10 | —1.146 | +2.308 | +2.577 | +71 5 | —1.558 | +2.663 | +3.085 |
| +67 20 | —1.161 | +2.321 | +2.595 | +71 10 | —1.568 | +2.672 | +3.098 |
| +67 30 | —1.176 | +2.334 | +2.613 | +71 15 | —1.579 | +2.681 | +3.111 |
| +67 40 | —1.191 | +2.347 | +2.632 | +71 20 | —1.589 | +2.690 | +3.124 |
| +67 50 | —1.206 | +2.360 | +2.650 | +71 25 | —1.600 | +2.699 | +3.138 |
| +68 0 | —1.222 | +2.373 | +2.669 | +71 30 | —1.611 | +2.709 | +3.152 |
| +68 10 | —1.238 | +2.387 | +2.689 | +71 35 | —1.622 | +2.718 | +3.165 |
| +68 20 | —1.254 | +2.401 | +2.708 | +71 40 | —1.633 | +2.728 | +3.179 |
| +68 30 | —1.270 | +2.415 | +2.729 | +71 45 | —1.644 | +2.737 | +3.193 |
| +68 40 | —1.287 | +2.429 | +2.749 | +71 50 | —1.656 | +2.747 | +3.207 |
| +68 50 | —1.303 | +2.444 | +2.769 | +71 55 | —1.667 | +2.757 | +3.222 |
| +69 0 | —1.321 | +2.458 | +2.790 | +72 0 | —1.679 | +2.767 | +3.236 |



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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | A. | B. | C. | Declination. | A. | B. | C. |
|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | |
| +72 0 | —1.679 | +2.767 | +3.236 | +74 30 | —2.079 | +3.112 | +3.742 |
| +72 5 | —1.690 | +2.777 | +3.251 | +74 35 | —2.094 | +3.125 | +3.762 |
| +72 10 | —1.702 | +2.787 | +3.265 | +74 40 | —2.110 | +3.138 | +3.782 |
| +72 15 | —1.714 | +2.797 | +3.280 | +74 45 | —2.126 | +3.152 | +3.802 |
| +72 20 | —1.725 | +2.807 | +3.295 | +74 50 | —2.142 | +3.166 | +3.822 |
| +72 25 | —1.738 | +2.818 | +3.310 | +74 55 | —2.158 | +3.180 | +5.843 |
| +72 30 | —1.750 | +2.828 | +3.325 | +75 0 | —2.174 | +3.194 | +3.864 |
| +72 35 | —1.762 | +2.839 | +3.341 | +75 5 | —2.191 | +3.208 | +3.885 |
| +72 40 | —1.774 | +2.849 | +3.356 | +75 10 | —2.207 | +3.223 | +3.906 |
| +72 45 | —1.787 | +2.860 | +3.372 | +75 15 | —2.224 | +3.237 | +3.928 |
| +72 50 | —1.799 | +2.871 | +3.388 | +75 20 | —2.241 | +3.252 | +3.950 |
| +72 55 | —1.812 | +2.882 | +3.404 | +75 25 | —2.259 | +3.267 | +3.972 |
| +73 0 | —1.825 | +2.893 | +3.420 | +75 30 | —2.276 | +3.282 | +3.994 |
| +73 5 | —1.838 | +2.904 | +3.437 | +75 35 | —2.294 | +3.297 | +4.017 |
| +73 10 | —1.851 | +2.915 | +3.453 | +75 40 | —2.312 | +3.313 | +4.039 |
| +73 15 | —1.864 | +2.927 | +3.470 | +75 45 | —2.330 | +3.328 | +4.063 |
| +73 20 | —1.877 | +2.938 | +3.487 | +75 50 | —2.348 | +3.344 | +4.086 |
| +73 25 | —1.891 | +2.950 | +3.504 | +75 55 | —2.367 | +3.360 | +4.110 |
| +73 30 | —1.904 | +2.961 | +3.521 | +76 0 | —2.385 | +3.376 | +4.134 |
| +73 35 | —1.918 | +2.973 | +3.538 | +76 5 | —2.404 | +3.392 | +4.158 |
| +73 40 | —1.932 | +2.985 | +3.556 | +76 10 | —2.423 | +3.409 | +4.182 |
| +73 45 | —1.946 | +2.997 | +3.574 | +76 15 | —2.443 | +3.425 | +4.207 |
| +73 50 | —1.960 | +3.009 | +3.592 | +76 20 | —2.462 | +3.442 | +4.232 |
| +73 55 | —1.974 | +3.022 | +3.610 | +76 25 | —2.482 | +3.460 | +4.258 |
| +74 0 | —1.989 | +3.034 | +3.628 | +76 30 | —2.502 | +3.477 | +4.284 |
| +74 5 | —2.003 | +3.047 | +3.646 | +76 35 | —2.523 | +3.494 | +4.310 |
| +74 10 | —2.018 | +3.060 | +3.665 | +76 40 | —2.543 | +3.512 | +4.336 |
| +74 15 | —2.033 | +3.072 | +3.684 | +76 45 | —2.564 | +3.530 | +4.363 |
| +74 20 | —2.048 | +3.085 | +3.703 | +76 50 | —2.585 | +3.548 | +4.390 |
| +74 25 | —2.063 | +3.098 | +3.722 | +76 55 | —2.607 | +3.567 | +4.418 |
| +74 30 | —2.079 | +3.112 | +3.742 | +77 0 | —2.628 | +3.585 | +4.445 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +77 0 | −2.628 | +3.585 | +4.445 | +3.934 | −2.070 | −4.445 |
| +77 5 | −2.650 | +3.604 | +4.474 | +3.956 | −2.089 | −4.474 |
| +77 10 | −2.672 | +3.623 | +4.502 | +3.978 | −2.108 | −4.502 |
| +77 15 | −2.695 | +3.643 | +4.531 | +4.000 | −2.128 | −4.531 |
| +77 20 | −2.718 | +3.662 | +4.561 | +4.023 | −2.147 | −4.561 |
| +77 25 | −2.741 | +3.682 | +4.590 | +4.046 | −2.167 | −4.590 |
| +77 30 | −2.764 | +3.702 | +4.620 | +4.070 | −2.187 | −4.620 |
| +77 35 | −2.787 | +3.723 | +4.651 | +4.093 | −2.208 | −4.651 |
| +77 40 | −2.812 | +3.743 | +4.682 | +4.117 | −2.228 | −4.682 |
| +77 45 | −2.836 | +3.764 | +4.713 | +4.142 | −2.249 | −4.713 |
| +77 50 | −2.861 | +3.786 | +4.745 | +4.166 | −2.270 | −4.745 |
| +77 55 | −2.886 | +3.807 | +4.777 | +4.191 | −2.292 | −4.777 |
| +78 0 | −2.911 | +3.829 | +4.810 | +4.217 | −2.314 | −4.810 |
| +78 5 | −2.937 | +3.851 | +4.843 | +4.242 | −2.336 | −4.843 |
| +78 10 | −2.963 | +3.873 | +4.877 | +4.268 | −2.358 | −4.877 |
| +78 15 | −2.989 | +3.896 | +4.911 | +4.295 | −2.381 | −4.911 |
| +78 20 | −3.016 | +3.919 | +4.945 | +4.321 | −2.404 | −4.945 |
| +78 25 | −3.043 | +3.943 | +4.980 | +4.348 | −2.428 | −4.980 |
| +78 30 | −3.070 | +3.966 | +5.016 | +4.376 | −2.451 | −5.016 |
| +78 35 | −3.098 | +3.990 | +5.052 | +4.404 | −2.475 | −5.052 |
| +78 40 | −3.127 | +4.015 | +5.089 | +4.432 | −2.500 | −5.089 |
| +78 45 | −3.155 | +4.040 | +5.126 | +4.461 | −2.525 | −5.126 |
| +78 50 | −3.185 | +4.065 | +5.164 | +4.490 | −2.550 | −5.164 |
| +78 55 | −3.214 | +4.090 | +5.202 | +4.520 | −2.575 | −5.202 |
| +79 0 | −3.244 | +4.116 | +5.241 | +4.550 | −2.601 | −5.241 |
| +79 5 | −3.275 | +4.142 | +5.280 | +4.580 | −2.627 | −5.280 |
| +79 10 | −3.306 | +4.169 | +5.321 | +4.611 | −2.654 | −5.321 |
| +79 15 | −3.337 | +4.196 | +5.361 | +4.643 | −2.681 | −5.361 |
| +79 20 | −3.369 | +4.224 | +5.403 | +4.675 | −2.709 | −5.403 |
| +79 25 | −3.401 | +4.252 | +5.445 | +4.707 | −2.736 | −5.445 |
| +79 30 | −3.434 | +4.280 | +5.487 | +4.740 | −2.765 | −5.487 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| Declination. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| 79 30 | −3.434 | +4.280 | +5.487 | +4.740 | −2.765 | −5.487 |
| 79 35 | −3.468 | +4.309 | +5.531 | +4.773 | −2.794 | −5.531 |
| 79 40 | −3.502 | +4.338 | +5.575 | +4.807 | −2.823 | −5.575 |
| 79 45 | −3.536 | +4.368 | +5.620 | +4.842 | −2.853 | −5.620 |
| 79 50 | −3.571 | +4.398 | +5.665 | +4.877 | −2.883 | −5.665 |
| 79 55 | −3.606 | +4.429 | +5.712 | +4.913 | −2.914 | −5.712 |
| 80 0 | −3.643 | +4.460 | +5.759 | +4.949 | −2.945 | −5.759 |

| Polaris. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ ″ | | | | | | |
| +88 43 0 | −33.162 | +29.899 | +44 650 | +34.465 | +28.386 | −44.650 |
| +88 43 30 | −33.382 | +30.090 | +44.942 | +34.687 | +28.577 | −44.942 |
| +88 44 0 | −33.606 | +30.283 | +45.238 | +34.911 | +28.770 | −45.238 |
| +88 44 30 | −33.833 | +30.478 | +45.536 | +35.137 | +28.965 | −45.536 |
| +88 45 0 | −34.064 | +30.677 | +45.841 | +35.367 | +29.163 | −45.841 |
| +88 45 30 | −34.296 | +30.877 | +46.148 | +35.600 | +29.363 | −46.148 |
| +88 46 0 | −34.533 | +31.081 | +46.460 | +35.837 | +29.569 | −46.460 |
| +88 46 30 | −34.772 | +31.287 | +46.776 | +36.076 | +29.774 | −46.776 |
| +88 47 0 | −35.014 | +31.496 | +47.095 | +36.318 | +29.983 | −47.095 |
| +88 47 30 | −35.259 | +31.708 | +47.421 | +36.565 | +30.195 | −47.421 |
| +88 48 0 | −35.504 | +31 920 | +47.748 | +36.814 | +30.410 | −47.748 |
| +88 48 30 | −35.762 | +32.142 | +48.085 | +37.067 | +30.628 | −48.085 |
| +88 49 0 | −36.020 | +32.364 | +48.423 | +37.324 | +30.850 | −48.423 |
| +88 49 30 | −36.280 | +32.588 | +48.769 | +37.584 | +31.074 | −48.769 |
| +88 50 0 | −36.551 | +32.806 | +49.115 | +37.847 | +31.302 | −49.115 |
| +88 50 30 | −36.820 | +33.037 | +49.470 | +38 116 | +31.533 | −49.470 |
| +88 51 0 | −37.090 | +33.270 | +49.825 | +38.387 | +31.765 | −49.825 |
| +88 51 30 | −37.368 | +33.507 | +50.190 | +38.664 | +32.003 | −50.190 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| 43 Cephei. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +85 40 | −9.343 | +9.373 | +13.235 | +10.649 | −7.858 | −13.235 |
| +85 41 | −9.382 | +9 407 | +13.286 | +10.688 | −7.892 | −13.286 |
| +85 42 | −9.421 | +9.440 | +13.337 | +10.727 | −7 925 | −13.337 |
| +85 43 | −9.461 | +9.474 | +13.389 | +10 766 | −7.960 | −13.389 |
| +85 44 | −9.500 | +9.508 | +13.441 | +10.806 | −7.994 | −13.441 |
| +85 45 | −9.540 | +9.543 | +13.493 | +10.845 | −8.028 | −13.493 |
| +85 46 | −9.580 | +9.578 | +13.547 | +10.886 | −8.063 | −13.547 |
| +85 47 | −9.621 | +9.613 | +13.600 | +10.927 | −8.098 | −13.600 |
| +85 48 | −9 662 | +9.648 | +13.654 | +10.968 | −8.133 | −13.654 |
| +85 49 | −9.703 | +9.683 | +13.708 | +11.009 | −8.169 | −13.708 |

| Gr. 750. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +85 16 | −8.495 | +8.642 | +12.119 | +9.801 | −7.127 | −12.119 |
| +85 17 | −8.528 | +8.670 | +12.161 | +9.834 | −7.155 | −12.161 |
| +85 18 | −8.560 | +8.698 | +12.204 | +9.866 | −7.183 | −12.204 |
| +85 19 | −8.593 | +8.727 | +12.247 | +9.899 | −7.212 | −12.247 |
| +85 20 | −8.626 | +8.755 | +12.291 | +9.932 | −7.240 | −12.291 |

| Gr. 944. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +85 8 | −8.243 | +8.425 | +11.787 | +9.551 | −6.908 | −11.787 |
| +85 9 | −8.274 | +8.452 | +11.828 | +9.582 | −6.934 | −11.828 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| 51 Cephei. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ ″ | | | | | | |
| +87 12 30 | —14.881 | +14.146 | +20.532 | +16.189 | —12.631 | —20.532 |
| +87 12 0 | —14.835 | +14.106 | +20.472 | +16.143 | —12.592 | —20.472 |
| +87 11 30 | —14.789 | +14.067 | +20.410 | +16.097 | —12.552 | —20.410 |
| +87 11 0 | —14.743 | +14.027 | +20.340 | +16.051 | —12.513 | —20.340 |

| 25 Camelop. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +82 37 | —5 192 | +5.796 | +7.782 | +6.498 | —4.281 | —7.782 |
| +82 36 | —5.183 | +5.781 | +7.764 | +6.485 | —4.269 | —7.764 |
| +82 35 | —5.173 | +5.767 | +7.747 | +6.472 | —4.258 | —7.747 |

| 32[a] Camelop. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +84 0 | —6.554 | +6.969 | +9.567 | +7.860 | —5.454 | —9.567 |
| +83 59 | —6.534 | +6 952 | +9.540 | +7.840 | —5.437 | —9.540 |
| +83 58 | —6.514 | +6.935 | +9.514 | +7.820 | —5.420 | —9.514 |
| +83 57 | —6.494 | +6.917 | +9.488 | +7.800 | —5.402 | —9.488 |
| +83 56 | —6.474 | +6.900 | +9 462 | +7.780 | —5 385 | —9.462 |
| +83 55 | —6.455 | +6.884 | +9.436 | +7.760 | —5.368 | —9.436 |
| +83 54 | —6.435 | +6.867 | +9.410 | +7.740 | —5.352 | —9.410 |
| +83 53 | —6.415 | +6.850 | +9.385 | +7.721 | —5.335 | —9.385 |
| +83 52 | —6.396 | +6.833 | +9.360 | +7.702 | —5.318 | —0.360 |
| +83 51 | —6.377 | +6.816 | +9.334 | +7.683 | —5.302 | —9.334 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| 1 Draconis. | | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|---|
| Declination. | | A. | B. | C. | A. | B. | C. |
| ° | ′ | | | | | | |
| +81 | 49 | —4.615 | +5.297 | +7.025 | +5.920 | —3.782 | —7.025 |
| +81 | 48 | —4.604 | +5.288 | +7.011 | +5.909 | —3.773 | —7.011 |
| +81 | 47 | —4.593 | +5.279 | +6.997 | +5.899 | —3.764 | —6.997 |
| +81 | 46 | —4.582 | +5.269 | +6.983 | +5.888 | —3.754 | —6.983 |
| +81 | 45 | —4.571 | +5.260 | +6.969 | +5.877 | —3.745 | —6.969 |
| +81 | 44 | —4.561 | +5.251 | +6.955 | +5.866 | —3.736 | —6.955 |
| +81 | 43 | —4.550 | +5.242 | +6.941 | +5.856 | —3.727 | —6.941 |

| 6 Urs. Min. | | | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|---|---|
| Declination. | | | A. | B. | C. | A. | B. | C. |
| ° | ′ | ″ | | | | | | |
| +88 | 18 | 30 | —24.954 | +22.907 | +33.874 | +26.300 | —21.349 | —33.874 |
| +88 | 18 | 0 | —24.830 | +22.798 | +33.709 | +26.175 | —21.240 | —33.709 |
| +88 | 17 | 30 | —24.705 | +22.690 | +33.544 | +26.050 | —21.133 | —33.544 |
| +88 | 17 | 0 | —24.582 | +22.584 | +33.381 | +25.927 | —21.026 | —33.381 |
| +88 | 16 | 30 | —24.460 | +22.479 | +33.220 | +25.805 | —20.921 | —33.220 |
| +88 | 16 | 0 | —24.339 | +22.374 | +33.060 | +25.684 | —20.817 | —33.060 |
| +88 | 15 | 30 | —24.220 | +22.270 | +32.902 | +25.563 | —20.713 | —32.902 |
| +88 | 15 | 0 | —24.101 | +22.168 | +32.745 | +25.445 | —20.611 | —32.745 |
| +88 | 14 | 30 | —23.983 | +22.067 | +32.590 | +25.327 | —20.510 | —32.590 |
| +88 | 14 | 0 | —23.867 | +21.966 | +32.437 | +25.211 | —20.409 | —32.437 |
| +88 | 13 | 30 | —23.751 | +21.866 | +32.284 | +25.095 | —20.310 | —32.284 |
| +88 | 13 | 0 | —23.637 | +21.768 | +32.134 | +24.982 | —20.212 | —32.134 |
| +88 | 12 | 30 | —23.525 | +21.670 | +31.985 | +24.869 | —20.114 | —31.985 |
| +88 | 12 | 0 | —23.413 | +21.573 | +31.836 | +24.756 | —20.018 | —31.836 |
| +88 | 11 | 30 | —23.302 | +21.477 | +31.690 | +24.645 | —19.922 | —31.690 |
| +88 | 11 | 0 | —23.192 | +21.382 | +31.544 | +24.535 | —19.826 | —31.544 |
| +88 | 10 | 30 | —23.082 | +21.288 | +31.400 | +24.425 | —19.732 | —31.400 |
| +88 | 10 | 0 | —22.975 | +21.194 | +31.258 | +24.318 | —19.640 | —31.258 |

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## TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.

| ε Urs. Min. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +82 13 | −4.889 | +5.534 | +7.384 | +6.193 | −4.021 | −7.394 |
| +82 12 | −4.877 | +5.523 | +7.368 | +6.183 | −4.008 | −7.368 |
| +82 11 | −4.865 | +5.512 | +7.352 | +6.173 | −3.995 | −7.342 |

| δ Urs. Min. | Below Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ ″ | | | | | | |
| +86 36 30 | −12.129 | +11.773 | +16.907 | +13.435 | −10.258 | −16.907 |
| +86 37 0 | −12.160 | +11.800 | +16.955 | +13.466 | −10.285 | −16.955 |
| +86 37 30 | −12.192 | +11.828 | +16.992 | +13.498 | −10.313 | −16.992 |

| λ Urs. Min. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ ″ | | | | | | |
| +88 57 30 | −41.008 | +36.663 | +55.007 | +42.313 | −35.148 | −55.007 |
| +88 58 0 | −41.344 | +36.952 | +55.450 | +42.649 | −35.437 | −55.450 |
| +88 58 30 | −41.684 | +37.248 | +55.901 | +42.990 | −35.733 | −55.901 |
| +88 59 0 | −42.027 | +37.547 | +56.360 | +43.337 | −36.032 | −56.360 |
| +88 59 30 | −42.384 | +37.851 | +56.825 | +43.690 | −36.336 | −56.825 |
| +89 0 0 | −42.742 | +38.160 | +57.298 | +44.047 | −36.645 | −57.298 |
| +89 0 30 | −43.107 | +38.473 | +57.780 | +44.413 | −36.960 | −57.780 |
| +89 1 0 | −43.478 | +38.794 | +58 270 | +44.783 | −37.280 | −58.270 |
| +89 1 30 | −43.855 | +39.120 | +58.768 | +45.162 | −37.604 | −58.768 |
| +89 2 0 | −44.240 | +39.450 | +59.275 | +45.524 | −37.936 | −59.275 |

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**TRANSIT FACTORS FOR COLUMBIA COLLEGE OBSERVATORY.**

| 76 Draconis. | Above Pole. | | | Below Pole. | | |
|---|---|---|---|---|---|---|
| Declination. | A. | B. | C. | A. | B. | C. |
| ° ′ | | | | | | |
| +82 7 | −4.817 | +5.472 | +7.291 | +6.123 | −3.958 | −7.291 |
| +82 8 | −4.829 | +5.483 | +7.306 | +6.135 | −3.968 | −7.306 |
| +82 9 | −4.841 | +5.493 | +7.322 | +6.147 | −3.978 | −7.322 |
| +82 10 | −4.853 | +5.503 | +7.337 | +6.159 | −3.988 | −7.337 |
| +82 11 | −4.865 | +5.513 | +7.353 | +6.171 | −3.998 | −7.353 |
| +82 12 | −4.877 | +5.523 | +7.368 | +6.183 | −4.008 | −7.368 |
| +82 13 | −4.889 | +5.534 | +7.384 | +6 195 | −4.019 | −7.384 |
| +82 14 | −4.901 | +5.544 | +7.400 | +6.207 | −4.029 | −7.400 |
| +82 15 | −4.913 | +5.554 | +7.416 | +6 219 | −4.040 | −7.416 |
| +82 16 | −4.925 | +5.565 | +7.432 | +6.231 | −4.050 | −7.432 |
| +82 17 | −4.937 | +5.575 | +7.447 | +6.243 | −4.061 | −7.447 |
| +82 18 | −4.949 | +5.586 | +7.463 | +6.255 | −4.071 | −7 463 |

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## TABLES FOR THE REDUCTION OF TRANSIT OBSERVATIONS BY THE METHOD OF LEAST SQUARES.

By HAROLD JACOBY.

The quantities given in the following tables are intended for the reduction of transit observations according to the method given in *Monthly Notices of the Royal Astronomical Society*, vol. lii., p. 114. These tables are good for any latitude, and are computed by the following formulæ:

$$p = \frac{1.3}{1 + 0.3 \sec^2 \delta}$$

$$m_1 = p \sec \delta, \qquad m_2 = p \tan \delta \sec \delta,$$

$$m_3 = p, \qquad m_4 = p \tan \delta,$$

$$m_5 = p \tan^2 \delta, \qquad m_6 = p \sec^2 \delta.$$

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## STAR TRANSIT TABLES.

| Declination. | $m_1$ | $m_2$ | $m_3$ | $m_4$ | $m_5$ | $m_6$ |
|---|---|---|---|---|---|---|
| —20° | +1.033 | —0.376 | +0.970 | —0.353 | +0.129 | +1.099 |
| —19 | +1.030 | —0.355 | +0.973 | —0.335 | +0.115 | +1.089 |
| —18 | +1.026 | —0.334 | +0.976 | —0.317 | +0.103 | +1.079 |
| —17 | +1.024 | —0.313 | +0.979 | —0.299 | +0.092 | +1.070 |
| —16 | +1.021 | —0.293 | +0.981 | —0.282 | +0.081 | +1.062 |
| —15 | +1.018 | —0.273 | +0.984 | —0.264 | +0.071 | +1.054 |
| —14 | +1.016 | —0.253 | +0.986 | —0.246 | +0.061 | +1.047 |
| —13 | +1.014 | —0.234 | +0.988 | —0.228 | +0.053 | +1.040 |
| —12 | +1.012 | —0.215 | +0.990 | —0.210 | +0.045 | +1.034 |
| —11 | +1.010 | —0.196 | +0.991 | —0.193 | +0.037 | +1.029 |
| —10 | +1.008 | —0.178 | +0.993 | —0.175 | +0.031 | +1.024 |
| — 9 | +1.007 | —0.159 | +0.994 | —0.157 | +0.025 | +1.019 |
| — 8 | +1.005 | —0.141 | +0.996 | —0.140 | +0.020 | +1.015 |
| — 7 | +1.004 | —0.123 | +0.997 | —0.122 | +0.015 | +1.012 |
| — 6 | +1.003 | —0.105 | +0.998 | —0.105 | +0.011 | +1.008 |
| — 5 | +1.002 | —0.088 | +0.998 | —0.087 | +0.008 | +1.006 |
| — 4 | +1.001 | —0.070 | +0.999 | —0.070 | +0.005 | +1.004 |
| — 3 | +1.001 | —0.052 | +0.999 | —0.052 | +0.003 | +1.002 |
| — 2 | +1.000 | —0.035 | +1.000 | —0.035 | +0.001 | +1.001 |
| — 1 | +1.000 | —0.017 | +1.000 | —0.017 | 0.000 | +1.000 |
| 0 | +1.000 | 0.000 | +1.000 | 0.000 | 0.000 | +1.000 |
| + 1 | +1.000 | +0.017 | +1.000 | +0.017 | 0.000 | +1.000 |
| + 2 | +1.000 | +0.035 | +1.000 | +0.035 | +0.001 | +1.001 |
| + 3 | +1.001 | +0.052 | +0.999 | +0.052 | +0.003 | +1.002 |
| + 4 | +1.001 | +0.070 | +0.999 | +0.070 | +0.005 | +1.004 |
| + 5 | +1.002 | +0.088 | +0.998 | +0.087 | +0.008 | +1.006 |
| + 6 | +1.003 | +0.105 | +0.998 | +0.105 | +0.011 | +1.008 |
| + 7 | +1.004 | +0.123 | +0.997 | +0.122 | +0.015 | +1.012 |
| + 8 | +1.005 | +0.141 | +0.996 | +0.140 | +0.020 | +1.015 |
| + 9 | +1.007 | +0.159 | +0.994 | +0.157 | +0.025 | +1.019 |
| +10 | +1.008 | +0.178 | +0.993 | +0.175 | +0.031 | +1.024 |

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## STAR TRANSIT TABLES.

| Declination. | $m_1$ | $m_2$ | $m_3$ | $m_4$ | $m_5$ | $m_6$ |
|---|---|---|---|---|---|---|
| +10° | +1.008 | +0.178 | +0.993 | +0.175 | +0.031 | +1.024 |
| +11 | +1.010 | +0.196 | +0.991 | +0.193 | +0.037 | +1.029 |
| +12 | +1.012 | +0.215 | +0.990 | +0.210 | +0.045 | +1.034 |
| +13 | +1.014 | +0.234 | +0.988 | +0.228 | +0.053 | +1.040 |
| +14 | +1.016 | +0.253 | +0.986 | +0.246 | +0.061 | +1.047 |
| +15 | +1.018 | +0.273 | +0.984 | +0.264 | +0.071 | +1.054 |
| +16 | +1.021 | +0.293 | +0.981 | +0.282 | +0.081 | +1.062 |
| +17 | +1.024 | +0.313 | +0.979 | +0.299 | +0.092 | +1.070 |
| +18 | +1.026 | +0.334 | +0.976 | +0.317 | +0.103 | +1.079 |
| +19 | +1.029 | +0.355 | +0.973 | +0.335 | +0.115 | +1.089 |
| +20 | +1.03[illegible] | +0.376 | +0.970 | +0.353 | +0.129 | +1.099 |
| +21 | +1.03[illegible] | +0.398 | +0.967 | +0.371 | +0.142 | +1.110 |
| +22 | +1.03[illegible] | +0.420 | +0.964 | +0.389 | +0.157 | +1.121 |
| +23 | +1.04[illegible] | +0.443 | +0.960 | +0.408 | +0.173 | +1.133 |
| +24 | +1.047 | +0.466 | +0.956 | +0.426 | +0.190 | +1.146 |
| +25 | +1.051 | +0.490 | +0.952 | +0.444 | +0.207 | +1.159 |
| +26 | +1.055 | +0.514 | +0.948 | +0.462 | +0.226 | +1.174 |
| +27 | +1.059 | +0.540 | +0.944 | +0.481 | +0.245 | +1.188 |
| +28 | +1.063 | +0.565 | +0.939 | +0.499 | +0.265 | +1.204 |
| +29 | +1.068 | +0.592 | +0.934 | +0.518 | +0.287 | +1.221 |
| +30 | +1.072 | +0.619 | +0.929 | +0.536 | +0.310 | +1.238 |
| +31 | +1.077 | +0.647 | +0.923 | +0.555 | +0.333 | +1.256 |
| +32 | +1.082 | +0.676 | +0.917 | +0.573 | +0.358 | +1.276 |
| +33 | +1.087 | +0.706 | +0.911 | +0.592 | +0.384 | +1.296 |
| +34 | +1.092 | +0.736 | +0.905 | +0.610 | +0.412 | +1.317 |
| +35 | +1.097 | +0.768 | +0.898 | +0.629 | +0.440 | +1.339 |
| +36 | +1.102 | +0.801 | +0.891 | +0.648 | +0.471 | +1.362 |
| +37 | +1.107 | +0.834 | +0.884 | +0.666 | +0.502 | +1.386 |
| +38 | +1.112 | +0.869 | +0.877 | +0.685 | +0.535 | +1.412 |
| +39 | +1.118 | +0.905 | +0.869 | +0.703 | +0.570 | +1.438 |
| +40 | +1.123 | +0.942 | +0.860 | +0.722 | +0.606 | +1.466 |

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## STAR TRANSIT TABLES.

| Declination. | $m_1$ | $m_2$ | $m_3$ | $m_4$ | $m_5$ | $m_6$ |
|---|---|---|---|---|---|---|
| +40° | +1.123 | +0.942 | +0.860 | +0.722 | +0.606 | +1.466 |
| +41 | +1.128 | +0.891 | +0.852 | +0.740 | +0.644 | +1.495 |
| +42 | +1.134 | +1.021 | +0.842 | +0.758 | +0.683 | +1.525 |
| +43 | +1.139 | +1.062 | +0.833 | +0.777 | +0.724 | +1.557 |
| +44 | +1.144 | +1.105 | +0.823 | +0.795 | +0.767 | +1.590 |
| +45 | +1.149 | +1.149 | +0.812 | +0.813 | +0.812 | +1.625 |
| +46 | +1.154 | +1.195 | +0.802 | +0.830 | +0.860 | +1.661 |
| +47 | +1.159 | +1.243 | +0.790 | +0.847 | +0.909 | +1.699 |
| +48 | +1.163 | +1.292 | +0.778 | +0.865 | +0.960 | +1.739 |
| +49 | +1.168 | +1.343 | +0.766 | +0.881 | +1.014 | +1.780 |
| +50 | +1.172 | +1.396 | +0.753 | +0.898 | +1.070 | +1.823 |
| +51 | +1.175 | +1.452 | +0.740 | +0.913 | +1.128 | +1.868 |
| +52 | +1.179 | +1.509 | +0.726 | +0.929 | +1.189 | +1.914 |
| +53 | +1.182 | +1.568 | +0.711 | +0.943 | +1.252 | +1.963 |
| +54 | +1.184 | +1.629 | +0.696 | +0.958 | +1.318 | +2.014 |
| +55 | +1.186 | +1.693 | +0.680 | +0.971 | +1.387 | +2.067 |
| +56 | +1.186 | +1.759 | +0.664 | +0.984 | +1.458 | +2.122 |
| +57 | +1.187 | +1.827 | +0.646 | +0.995 | +1.533 | +2.179 |
| +58 | +1.186 | +1.898 | +0.628 | +1.006 | +1.610 | +2.238 |
| +59 | +1.184 | +1.971 | +0.610 | +1.015 | +1.690 | +2.300 |
| +60 | +1.182 | +2.046 | +0.591 | +1.023 | +1.773 | +2.364 |
| +61 | +1.178 | +2.124 | +0.571 | +1.030 | +1.859 | +2.430 |
| +62 | +1.173 | +2.206 | +0.551 | +1.035 | +1.948 | +2.498 |
| +63 | +1.166 | +2.289 | +0.529 | +1.039 | +2.039 | +2.569 |
| +64 | +1.158 | +2.374 | +0.508 | +1.041 | +2.134 | +2.641 |
| +65 | +1.148 | +2.461 | +0.485 | +1.040 | +2.231 | +2.716 |
| +66 | +1.136 | +2.552 | +0.462 | +1.038 | +2.331 | +2.793 |
| +67 | +1.122 | +2.643 | +0.438 | +1.033 | +2.433 | +2.872 |
| +68 | +1.106 | +2.738 | +0.414 | +1.025 | +2.538 | +2.952 |
| +69 | +1.087 | +2.832 | +0.390 | +1.015 | +2.645 | +3.034 |
| +70 | +1.066 | +2.929 | +0.365 | +1.002 | +2.753 | +3.118 |

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## STAR TRANSIT TABLES.

| Declination. | $m_1$ | $m_2$ | $m_3$ | $m_4$ | $m_5$ | $m_6$ |
|---|---|---|---|---|---|---|
| +70° | +1.066 | +2.929 | +0.365 | +1.002 | +2.753 | +3.118 |
| +71 | +1.042 | +3.028 | +0.339 | +0.986 | +2.863 | +3.202 |
| +72 | +1.016 | +3.126 | +0.314 | +0.966 | +2.973 | +3.287 |
| +73 | +0.986 | +3.225 | +0.288 | +0.943 | +3.084 | +3.372 |
| +74 | +0.953 | +3.324 | +0.263 | +0.916 | +3.195 | +3.458 |
| +75 | +0.917 | +3.422 | +0.237 | +0.886 | +3.305 | +3.542 |
| +76 | +0.877 | +3.518 | +0.212 | +0.851 | +3.414 | +3.626 |
| +77 | +0.834 | +3.613 | +6.188 | +0.812 | +3.520 | +3.708 |
| +78 | +0.788 | +3.705 | +0.164 | +0.770 | +3.624 | +3.788 |
| +79 | +0.737 | +3.794 | +0.141 | +0.724 | +3.724 | +3.864 |
| +80 | +0.684 | +3.878 | +0.119 | +0.673 | +3.819 | +3.938 |
| +81 | +0.627 | +3.959 | +0.098 | +0.619 | +3.909 | +4.006 |
| +82 | +0.566 | +4.031 | +0.079 | +0.561 | +3.992 | +4.070 |
| +83 | +0.503 | +4.100 | +0.061 | +0.499 | +4.068 | +4.129 |
| +84 | +0.437 | +4.159 | +0.046 | +0.435 | +4.135 | +4.181 |
| +85 | +0.368 | +4.210 | +0.032 | +0.367 | +4.194 | +4.226 |
| +86 | +0.298 | +4.255 | +0.021 | +0.296 | +4.244 | +4.264 |
| +87 | +0.225 | +4.287 | +0.012 | +0.225 | +4.282 | +4.294 |
| +88 | +0.151 | +4.312 | +0.005 | +0.152 | +4.310 | +4.316 |
| +89 | +0.076 | +4.325 | +0.001 | +0.074 | +4.328 | +4.329 |
| +90 | 0.000 | +4.333 | 0.000 | 0.000 | +4.333 | +4.333 |
| +89 *s. p.* | −0.076 | +4.325 | +0.001 | −0.074 | +4.328 | +4.329 |
| +88 *s. p.* | −0.151 | +4.312 | +0.005 | −0.152 | +4.310 | +4.316 |
| +87 *s. p.* | −0.225 | +4.287 | +0.012 | −0.225 | +4.282 | +4.294 |
| +86 *s. p.* | −0.298 | +4.255 | +0.021 | −0.296 | +4.244 | +4.264 |
| +85 *s. p.* | −0.368 | +4.210 | +0.032 | −0.367 | +4.194 | +4.226 |
| +84 *s. p.* | −0.437 | +4.159 | +0.046 | −0.435 | +4.135 | +4.181 |
| +83 *s. p.* | −0.503 | +4.100 | +0.061 | −0.499 | +4.068 | +4.129 |
| +82 *s. p.* | −0.566 | +4.031 | +0.079 | −0.561 | +3.992 | +4.070 |
| +81 *s. p.* | −0.627 | +3.959 | +0.098 | −0.619 | +3.909 | +4.006 |
| +80 *s. p.* | −0.684 | +3.878 | +0.119 | −0.673 | +3.819 | +3.938 |

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# ABSTRACTS.

## Analytical Chemistry, by E. Waller.

*Remedy for "Bumping."* Pieszezek (*Chem. Zeit.*, xv., 1126). Hang in the liquid (open end downward) a tube closed at one end, 5 to 8 cm. in length and 5 to 10 mm. bore, the size of the tube depending upon the dimensions of the vessel used. If allowed to cool down the tube should be filled with air afresh on heating up again.

*Solubility of Various Kinds of Glass in Water.* Mylius and Foster (*Zts. f. Instrumentenk*, 1891, 311). The method used was determination of alkalinity of water kept in contact with the specimens. The action, which varied very much with different glasses, was at first tolerably decided, becoming slower after a time.

Kohlrausch (*Berichte*, xxiv., 3560) has made some similar experiments, determining the degree of action by the electrical conductivity of the water used. It was found that the hygroscopic properties of the different glasses in powder were essentially in the same order as their solubilities in water.

*Preparing Hydrobromic Acid.* Newth (*Chemical News*, lxiv., 215). A small platinum wire is wound into a coil and inserted in a tube in such a manner that a current of electricity sufficient to heat the wire to redness can be passed through it. A mixture of hydrogen and bromine—obtained by passing H through Br is then passed through the tube, and when air has been expelled the electric current is turned on. HBr results, which may be absorbed in water.

*$BaO_2$ and $H_2O_2$ as Reagents.* Donath (*Chem. Zeit.*, xv., 1085) claims priority in the use of $BaO_2$ for attacking chromite as well as slags, clays, etc. For chromite about ten times the weight of the sample only is necessary, if the reagent is of good quality. The mixture may be heated over a Bunsen burner. The iodometric estimation of the chromium is regarded by the author as preferable to the ammonio-ferrous sulphate method.

$H_2O_2$ is recommended as an oxidant for ferrous salts, for removing an excess of $(NH_4)_2S$, oxidizing $H_3AsO_3$, etc.

*Potassium Ferro- and Ferricyanide as Reagents.* Luckow (*Chem. Zeit.*, xv., 1491). Zn can be determined gravimetrically or volumetrically by ferricyanide in presence of Pb, in a solution acidulated with $HNO_3$ or $HC_2H_3O_2$. In the filtrate the Pb may be similarly estimated by use of ferrocyanide. $SnO_2$ may be determined by ferrocyanide in presence of $Sb_2O_5$ and $As_2O_5$ if the solution is first evaporated with $H_2C_2O_4$, redissolved, and a little $H_2SO_4$ added. The purity of either potassium ferro- or ferricyanide is often open to question. Daylight or heating above 50° to 60° C. may convert ferricyanide into ferrocyanide. The presence of the latter may be recognized by testing with uranium salts or lead salts, which should show no coloration or precipitate.

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The indicators for the volumetric use of these two salts are of two classes: The one class determine whether the metal has been precipitated; the other, when an excess of the reagent has been used. Among the first are the alkaline sulphides; among the second the author finds $Cu(C_2H_3O_2)_2$ acidified with $HC_2H_3O_2$ to be useful. The solution titrated should be 20 to 30 c.c. in bulk and contain 0.1 to 0.15 gramme of the metal to be determined. If filtration is required the ferricyanides filter the more readily.

*Making Lakmoid.* Schaerges (*Chem. Zeit.*, xv., No. 95) heats $NaNO_2$ and resorcin without addition of water to not over 110°. After cooling the melt is dissolved in water and undecomposed resorcin removed by shaking with ether. The reagent is purified by acidification of the water solution as usual.

*Alkalimetric and Acidimetric Solutions.* Borntrager (*Fres. Zts.*, xxxi., 43). To verify normal or fractional normal solutions many plans are used:

For *normal, etc., HCl,* gravimetric or volumetric with $AgNO_3$.

For *normal, etc., $H_2C_2O_4$*, gravimetric with ammonia and $CaCl_2$, also by volumetric $K_2Mn_2O_8$.

For *normal, etc., $H_2SO_4$*, gravimetric or volumetric with $BaCl_2$.

For *normal, etc., $HNO_3$*. Neutralize exactly with $K_2CO_3$, evaporate and ignite with weighed amount of $SiO_2$ and weigh.

A similar method with $SrCO_3$ is used, in which the $Sr(NO_3)_2$ is washed with a mixture of equal parts of alcohol and ether before adding the $SiO_2$. Exact neutralization with $Ba(OH)_2$ or $Ca(OH)_2$ and gravimetric determination of the amount of base converted to nitrate may be used.

Also the nitrometer and conversion to ammonia, estimated gravimetrically by $PtCl_4$.

For *normal, etc., KOH, $K_2CO_3$*, or ammonium solution. Neutralize by HCl and determine gravimetrically by $PtCl_4$.

For *normal, etc., NaOH.* Neutralize with HCl or $H_2SO_4$, evaporate to dryness and weigh.

$Ba(OH)_2$ solutions cannot be stronger than fifth normal, $Ca(OH)_2$ solutions than thirtieth normal. Determine gravimetrically as $BaSO_4$ or $Ca_2C_2O_4$ respectively.

To determine the strength irrespective of possible impurities one may use:

For *Normal, etc., Acids*:

Dry *$Na_2CO_3$* or *$NaHCO_3$*. Either should be ignited gently before use. The chief impurities are likely to be NaCl, $Na_2SO_4$, or $H_2O$, though $SiO_2$, K, Ca, Mg, Fe and Al salts may be present.

*$K_2CO_3$* obtained by ignition of weighed amounts of $KHC_4H_4O_6$.

*$CaCO_3$*. Pulverized double refracting spar dried at 100°; also obtained by ignition of weighed quantities of $CaC_2O_4$ or $CaC_4H_4O_6$, prepared by precipitation, using the purest materials possible; also that obtained by precipitating pure $CaCl_2$ with $(NH_4)_2CO_3$ at a boiling heat.

*For Normal, etc., Alkalies.* $H_2C_2O_4 \cdot 2H_2O$. Possible impurities, Ca, K, $H_2SO_4$ and sulphates; other material which will not sublime, effloresced crystals. (Fresenius asserts that some efflorescence may occur at 20° C.). Purify by repeated crystallization, or by partially dis-

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solving in a limited amount of alcohol, crystallizing from the filtrate, and re-crystallizing from water solution. Or by crystallizing from a boiling solution containing 10 to 15 per cent. HCl, washing, and then re-crystallizing from water solution. The sublimed acid (anhydrous $H_2C_2O_4$) has been used by some. Others check the purity of the acid by drying some at 100° and weighing. Decomposition of the solutions by standing may be prevented by heating them in closed flasks to 60° or 70° C. for thirty minutes.

$KHC_2O_4$, $H_2O$ is liable to the same impurities. It is more efflorescent.

$KHC_2O_4$, $H_2CO_4$, $2H_2O$ is open to the same objections; a determination of water should be made every time it is used. For complete drying 128° C. is needed.

*Salts of heavy metals* in solution, after precipitation by $H_2S$. The difficulty with these consists in getting absolutely pure salts, free from basic salt and free acid, and containing the correct amount of water of crystallization. Similar objections are made to the use of $CuSO_4$ in solution with neutral $K_2SO_4$ or $Na_2SO_4$, where, after electrolyzing, the free acid is calculated from the amount of Cu deposited.

$KHC_4H_4O_6$ is preferred by the author as non-hygroscopic, and containing no water of crystallization. It may be prepared by addition of an excess of conc. $KC_2H_3O_2$ solution to conc. solution of $H_2C_4H_4O_6$, washing the precipitate with (50 per cent.) alcohol, and drying. The author's method of purification is boiling the purest obtainable salt for several hours with one part water and one tenth part HCl (Sp. gr. 1.13) cooling with stirring, draining off and re-crystallizing from water solution. The salt may be used directly for alkalies or ignited, for acids, with litmus paper as indicator.

*Colorimetric Determination of Small Quantities of Iron.* Riban. (*Bull. Soc. Chim* [3] VI., 916.) Methods based on the intensity of coloration imparted by ferric sulphocyanate, acetate or alkaline tartrate are unsuited for even approximate estimations of iron, these salts being partially decomposed by the degree of dilution necessary for the performance of the test.

*Alumina and Iron Oxide in Fertilizers.* Krug (*Jour. Anal. and App. Chem.*, v., 671.), has investigated several of the methods proposed. Glaser's "alcohol method" and its various modifications (*vide* QUARTERLY xi., 273; xii., 262; xiii., 74) were found unsatisfactory. The best method is said to be that of McElroy, practically that of Ogilvie (Crookes' *Select Methods* 2d ed., p. 539.) It consists in placing 100 c.c. of nitric acid solution (=1 gm.) of the substance in a 500 c.c. flask and adding some $NH_4NO_3$ and sufficient molybdate to precipitate the $P_2O_5$. After standing over night at the temperature of the laboratory, the solution is made up to the mark, filtered through a dry filter, and lots of 100 c.c. each, taken for further treatment. To each of these $NH_4NO_3$ and ammonia are added, keeping the solution cool. The precipitates of ferric and aluminic hydrates, should be redissolved in dilute $HNO_3$ (containing $NH_4NO_3$) and reprecipitated by ammonia to remove molybdic acid. The latter will accompany the precipitate if heat is used in the precipitation. The precipitate from one lot may be ignited

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and weighed, and that from another lot may be dissolved in $H_2SO_4$, reduced with Zn and titrated for Fe.

*Commercial Aluminum.* Regelsberger (*Zts. Angew. Chem.*, 1891, 360). *Silicon.* Dissolve 2 to 4 gms. in a Pt. dish with six times its weight of KOH and 50 c.c. water. Neutralize with HCl, evaporate to dryness, etc. The resulting $SiO_2$ should be tested with HFl. It has been found that by solution in HCl, evaporation to dryness, redissolving and filtering, the residue (consisting of Si, $SiO_2$ and $Fe_2O_3$) has the same weight as the pure $SiO_2$ obtainable from a sample. Si probably occurs in two forms in commercial aluminum, since some Si as well as $SiO_2$ is always found in the residue obtained by dissolving in HCl.

*Iron.* Dissolve 3 gms. in 50 c.c. of 40 per cent. KOH solution in a 500 c.c. flask, add 200 c.c. dilute $H_2SO_4$ (sp. gr. 1.16), warm until clear, cool and titrate with $K_2Mn_2O_8$.

*Aluminum.* Dissolve 2 gms. in water containing 12 gms. KOH and dilute to 200 c.c. Take 500 c.c. of this solution and boil with excess of $NH_4NO_3$, filter, wash, ignite and weigh. Then pulverize and ignite. Take aliquot parts; boil one with water and estimate any alkali present; fuse another part with $KHSO_4$, dissolve in water and filter off and weigh $SiO_2$. Deduct alkali and $SiO_2$ from the weight of the original precipitate.

*Decomposing Chromite.* Jannasch and Vogtherr (*Berichte*, xxiv., 3206). Chromite, as well as several other minerals, can be decomposed by heating for 8 to 10 hours at 250° C., or over, in a sealed tube or platinum digester, with $NH_4Cl$ and concentrated HCl. The proportions used for chromite are 1 gm. of mineral, 2 gms. $NH_4Cl$, and 10 c.c. conc. HCl.

*Decomposing Minerals Containing Titanium.* Jones (*J. Anal. and App. Chem.*, v., 622). Heating 2 gms. of the pulverized mineral with 20 c.c. water and 20 c.c. conc. $H_2SO_4$ in a pressure bottle at 200° C. for two hours is recommended. Longer heating at a lower temperature is also efficient.

*Colorimetric for Titanium.* Dunnington (*Jour. Am. Chem. Soc.*, xii). In making the estimation by Weller's method (*Berichte*, xv., 2592; *Cf.* QUARTERLY, xii., 264)—intensity of coloration produced by addition of $H_2O_2$—it was found that unless the melt obtained with $NaHSO_4$ was dissolved in (cold) $H_2SO_4$ of 5 per cent. strength or stronger, the estimation was incorrect. The formation of metatitanic acid was found to be the cause. For a correct estimation, therefore, $H_2SO_4$ of at least 5 per cent. must be used in dissolving the melt.

*Separation of Manganese.* Jannasch and Franzek (*Berichte*, xxiv., 3205) have already recorded the fact that Mn may be separated from Zn by the use of $H_2O_2$ in a strongly ammoniacal solution containing $NH_4Cl$. Attempts to effect separation in the same manner from Ni or Co, or both, showed that it could only be accomplished in a double cyanide solution of the sulphates, and not in any other of the solutions tried.



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*Ferrocyanide Titration of Zinc.* Blum (*Fres. Zts.*, xxxi., 60). Render solution (containing no members of the $H_2S$ group) ammoniacal, add a few drops of Br water, then 5 c.c, of Moldenhauer's mixture; boil, filter, and titrate. The precipitate contains all the iron, manganese and alkaline earths. Moldenhauer's mixture contains per 100 c.c., 5 gms. solid ammonium carbonate, 5 gms. $NH_4Cl$ and 10 c.c. ammonia.

*Separation of Bismuth and Lead.* Remmler (*Berichte*, xxiv., 3554). $BiCl_3$ was found to be volatile at the temperature of boiling sulphur, while $PbCl_2$ is not. The mixed chlorides are inserted in a test tube, which is supported in a larger one containing sulphur heated to the vaporizing point, while a current of Cl is passed through the inner tube. In the course of an hour all the $BiCl_3$ will be volatilized. The separation can be effected, starting with metals as sulphides. In that case a preliminary treatment is necessary.

*Separation of Bismuth and Cadmium.* Jannasch and Etz (*Berichte*, xxiv., 3476). The mixed sulphides *absolutely dry* are heated in a tube in a current of Br. Bi $Br_3$ is volatilized and condensed in dilute HCl. The Cd $Br_2$ remaining unvolatilized is dissolved in dilute HCl and precipitated boiling with $Na_2CO_3$. The solution containing the Bi is evaporated two or three times with $HNO_3$, and precipitated boiling with $(NH_4)_2CO_3$ and ammonia.

*Analytical Separations of Arsenic, Mercury, etc.* Haack (*Fres. Zts*, xxxi., 79). As from Hg. Both elements should be in the highest state of oxidation. Supersaturate the solution with ammonia, and add drop by drop a moderately strong solution of KCy until the white precipitate is entirely dissolved. Add one-fourth the volume of ammonia and the same of alcohol, and then precipitate As with Mg mixture. $P_2O_5$ can be separated from Hg in the same manner.

$HNO_3$, HCl or Na may be separated from Hg, As or $P_2O_5$ by boiling the solid substance with solution of $Ba(OH)_2$ and filtering. For the acids the filtrate is saturated with $CO_2$ to remove excess of Ba, and the remaining Ba (combined as nitrate or chloride) separated by $H_2SO_4$, and from the weight of the precipitate the proportion of $HNO_3$ or HCl calculated. In the case of Na the Ba is separated as sulphate, and the filtrate therefrom evaporated, the resulting $Na_2SO_4$ being weighed. Na in a substance may be separated from Hg or As by mixing with $NH_4Cl$ and igniting to constant weight at a gentle heat. NaCl remains.

*Detection of Arsenic.* Thiele (*Liebig's Annalen*, cclvi., 55). If the "noble metals" and Ca are absent the test can be applied. Acidulate strongly with HCl, add sodium hypophosphite in the proportion of 1 gramme to every 10 c.c. of the solution, and warm on the water bath. A brown precipitate forms more or less promptly according to the proportion of As present. The sensitiveness of the test is increased by the addition of a crystal of KI.

*Testing Iron for Arsenic.* Sautermeister (*Chem. Zeit.*, xv., 1021). The German Pharmacopœia recommends dissolving in HCl and testing

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the H exolved as in the Marsh apparatus. The author finds that unless an excess of Zn is introduced, metallic As is precipitated, and no $AsH_3$ appears in the evolved gases.

*Sensitiveness of Various Tests for Arsenic.* Curtmann (*Pharm. Rundschau*, ix., 175).

Reagent.

| | $As_4O_6$ in c.c. | | | |
|---|---|---|---|---|
| | 00.1 Mg. | 0.001 Mg. | 0.001 Mg. | 0.0001 Mg. |
| $H_2S$ . . . . . | . | Sl yellow in 2 min. | Yellow in 15 min. | No reaction. |
| $AgNO_3$ . . . . . | | Sl. yellow in 6 min. | | |
| (Scheele's) $CuSO_4$ + Ammon. | Immediate p'p't. | Scarcely p'rc'ptible. | | |
| (Bettendorf's) $SnCl_2$ + HCl . | Slight brown. | No reaction. | | |
| (Gutzeit's) As $H_3$ on $AgNO_3$ . | | | Yellow stain in 30 min. | Barely perceptible in 1 hour. |

For pharmaceutical tests Bettendorf's is preferable.

*Separation of Platinum, etc., from the Non-Noble Metals.* Joly and Leidie (*C. Rend.*, cxii., 1259). The dilute HCl solution warmed to 60° C. receives the gradual addition of $KNO_2$. Pt first precipitates as $K_2PtCl_6$. After cooling and filtering the solution is warmed, and more $KNO_2$ is gradually added. This affords a precipitate containing Rh, Bi and Sn. Cool and filter, then add an excess of $KNO_2$ until the solution becomes alkaline when Fe and Cu are precipitated. The filtrate from these still contains Pt and Pd.

*Determination of Thallium.* Baubigny (*C. Rend.*, cxiii., Oct. 26, 1891). The iodide is insoluble in a 1 per cent. solution of KI and also in alcohol. It therefore suffices to precipitate with excess of KI solution, wash with a 1 per cent. solution of KI, and finally with alcohol of about 80 per cent.

*Sulphur Estimation.* Treadwell (*Berichte*, xxiv., 1937). The pulverized material is mixed with metallic iron (ferrum reductum) and the mixture heated for ten minutes in a boat inserted in a combustion tube, a current of $CO_2$ being passed through. The boat and contents are then placed in a flask, which is filled with hydrogen, and HCl is allowed to drop in slowly. The evolved gases are passed into ammoniacal $H_2O_2$ solution or $AgNO_3$. A blank test is necessary.

Craig's (*Chem. News*, lxiv., 266) method is also an "evolution" method after previous heating with zinc dust. 10 to 20 grammes of the pyrites (or similar material) is weighed out in an ignition tube of Bohemian glass. Five times its weight of zinc dust is introduced and the materials are mixed by means of a platinum wire. After covering with a layer of zinc dust, a rod (the end of which has been flattened to a disc) is inserted and wedged in place (by way of a handle) with asbestos yarn. The tube and contents are then heated gradually up to incan-

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descence in the flame of a Bunsen burner. After maintaining this heat for half a minute it is withdrawn gradually and cooled. All sulphates in the substance, as well as the higher sulphides, are thus converted into monosulphides from which all the S may be evolved as $H_2S$ by the action of HCl in a current of coal gas or other non-oxidizing gas.

*Phosphorus in Iron.* Hamilton (*J. S. C.*, I., x., 904). A series of experiments are detailed from which the author concludes: 1. That the carbonaceous matter in a solution of iron does not prevent the precipitation of properly oxidized phosphorus as ammonio-phosphomolybdate. 2. That the reason of the incomplete precipitation of phosphorus from a nitric acid solution of iron, which has not been evaporated to dryness and roasted, is that the phosphorus has not all been properly oxidized. 3. That in such solutions all the phosphorus can be completely oxidized and rendered precipitable, in the wet way, by means of certain oxidizing agents.

*Phosphoric Acid in Slags.* Edwards (*Chem. News*, lxiv., 275). Some slags which resisted the action of aqua regia decomposed easily on heating for an hour in a Kjeldahl flask with $H_2SO_4$ and a drop of metallic Hg. In the solution from this treatment the citro-magnesic solution gave a precipitate containing something other than $MgNH_4PO_4$. By dissolving in $HNO_3$ and titrating with uranium salt a satisfactory determination of $P_2O_5$ was effected.

*Silica in Presence of Iron.* Leclerc (*Comptes Rend.*, cxii., 1132). In the analysis of manufactured irons, and in some other cases, the silica obtained by evaporation of the solution to dryness is frequently contaminated with iron. This may be avoided by the addition of KCl in sufficient quantity to form a double potassium ferric chloride which salt does not readily decompose at the temperature of desiccation.

*Determining Silica in Substances Containing Fluorine.* Hampe (*Chem. Zeit.*, xv., 1521). Fuse 0.5 to 1 gramme of substance with 8 to 10 times its weight of borax for twenty minutes. A portion of the borax (which should, of course, be free from $SiO_2$) is used as a bed, and another portion as a cover, the remainder being mixed with the pulverized substance. After cooling, digest in hot water in a Pt. basin until the melt is disintegrated, an operation requiring about two days. Add half as much $NH_4Cl$ as the weight of borax taken, warm until there is no odor of ammonia, filter through Pt or caoutchouc funnel and wash. Reserve the insoluble portion. Evaporate the filtrate to dryness in platinum, heat to over 100° and redissolve in water. Render alkaline with $(NH_4)_2CO_3$, filter and evaporate again. Repeat this as long any precipitate is obtained. Unite the insoluble residue and all the precipitates, ignite, fuse with $Na_2CO_3$, dissolve in HCl, and evaporate to dryness for $SiO_2$ in the usual manner. It may be advisable to evaporate the filtrate to dryness to recover a small amount of $SiO_2$.

*Nitric Nitrogen and Total Nitrogen.* Boyer (*C. Rend.*, cxiii., 503, October, 1891). A nitrate, subjected to combustion after mixture with $CaC_2O_4$ and soda lime, affords about two thirds of its nitrogen as am-

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monia. If sulphur is added to the mixture, all is converted to ammonia. The mixture used is: S, 1 part; $CaC_2O_4$, 2 parts, and soda lime, 6 parts. The combustion tube is charged thus: At the rear end, 2 grammes $CaC_2O_4$, then 10 grammes powdered soda lime, then 10 grammes of the mixture mingled with the material to be analyzed (containing not more than the equivalent of 0.5 gramme of $NaNO_3$ or $KNO_3$), then 10 grammes of the mixture, then 10 grammes of soda lime, and finally an asbestos plug. The combustion can be completed in 40 minutes.

*Organic Matter in Water.* Young (*J. S. C. I.*, x., 884). For *total organic matter*, 1 litre of water receives the addition of 0.5 dried and ignited $Na_2CO_3$. It is then distilled in a conical iron still of 2 litres capacity, attached to a tin worm condenser. When 970 c.c. have distilled off, the still is cooled and the contents and washings evaporated to dryness in a platinum dish. The residue is dissolved in a little water, filtered through asbestos into a Pt. dish, the solution evaporated and dried at 150° C. for an hour, and weighed. This residue is dissolved in water, $H^2SO_4$ added, and standard permanganate (1 c.c. = 0.0001 grm. O) run in until the color is permanent for five minutes. The weight of oxygen lost, thus ascertained, is deducted from the loss on ignition, and the difference is total organic matter.

For *fixed organic matter* the proceeding is the same, except that the $Na_2CO_3$ is not added until the solution is transferred from the still.

For *volatile organic matter* the distillate from the fixed organic matter is is re-distilled after addition of 0.05 gm. $Na_2CO_3$ as in the case of "total," until 25 c.c. remains in the still, when it is treated as described under "total," except that it is unnecessary to to ascertain the oxygen lost by ignition. The result represents about two-thirds of the total volatile organic matter. The whole process depends on the point that the excess of $Na_2CO_3$ prevents the volatilization of organic matter with the steam.

The asbestos used should be carefully purified by boiling with HCl, washing, boiling with strong $Na_2CO_3$ solution, and washing again.

## MISCELLANEOUS.

BRIQUETTES FROM LIGNITE.—J. C. Newbury (*Rep. Min. Dep., Victoria, Australia*, 1890) finds that Brown Lignites cannot be made into Briquettes by pressure and tar, as they are too friable to handle after sustaining a pressure of 10.75 pounds per square inch. Has seen a good Briquette, not easily broken, said to have been made by heating the lignite to the temperature at which the tarry matters are formed, and passing it immediately to the moulds before they are given off.

E. G.

TANDEM TANKS FOR HOISTING WATER FROM FLOODED SLOPES, by J. H. Bowden, at Glen Summit meeting of American Institute of Mining Engineers, October, 1861:

"The water-hoisting tanks here described have been designed for removing large quantities of water from recently flooded mines, through their hoisting-slopes, with rapidity proportional to the capabilities of the

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hoisting machinery available, the tanks being adaptable to slopes of small sectional areas and varying pitches."

"The following features may be of interest to those operating mines liable to be flooded."

"1. The arrangement of doors on each tank by which it may be automatically filled by immersion at any point on the varying pitch of a slope, the water being retained while hoisting on the flat as well as on the steep pitches, and quickly and automatically discharged at the top."

"2. The arrangement, in connection with the above-mentioned doors, of side-wheels over the rear-wheels of each tank and of side-dumping tracks at the top of the hoist, for the automatic emptying and quick return of the tank."

"3. The arrangement of two or more tanks, one in front of the other, so as to give as large a capacity in a single hoist as the engine power will permit, yet without making any tank too large for the sectional area of the slope, or of unwieldy length, or of such a shape that it cannot easily pass over vertical curves, and without concentrating too much weight on any pair of wheels or on any point of the track."

"At the end of each tank is a large iron door of almost the full size of the end of the tank, opening inwards, so that when immersed the tanks fill almost instantly. To provide for holding the water while it is hoisted up flat pitches, a wooden door is attached to the front of each tank, opening outward. Each front door is attached to the door at the back by an iron rod, provided with a sliding link, so that the back door can open independently of the front; but the latter is held closed as long as the rear door is closed. This connecting rod passes through the front door and through a spiral spring in front of it, so that the amount of pressure necessary to keep the water from leaking out may be readily applied."

"The tanks are mounted on self oiling closed wheels, so arranged as to exclude water from the bearings while the tanks are immersed, and to retain the lubricant."

"Each tank is provided also with side-wheels, vertically over the rear axle, which have a gauge sufficiently wide to clear all other portions of the tank; and on the surface an elevated track is provided, upon which these dumping-wheels run and thus raise the rear end of each tank as much as may be necessary to dump the water into a trough between the tracks; the tilting forward of the tanks opening the back door and releasing the front one. The tanks while emptying rest on their forward wheels and on the dumping-wheels. By having the tracks at the surface slightly up-grade, the tanks will run back when empty, as soon as the rope is slackened. To allow this dumping, the hoisting-rope is attached to the tanks by a yoke reaching back on the sides and pivoting on the axle of the dumping-wheels, the tanks back of the first one being attached by eye-bars reaching from axle to axle of the dumping-wheels on the tanks. A stop is provided, to prevent the yoke on the forward tank from dropping and catching in the track when the rope is slackened."

"This plan of, 'tandem tanks' was designed and used to hoist about 25,000,000 gallons of water which had been admitted to extinguish a mine fire in one of the Susquehanna Coal Company's mines. The slope was small in section, and 3200 feet long, with single track, and

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with pitches varying from 4 to 20 degrees. The hoisting plant consisted of a pair of 26 inches by 60 inches direct acting engines with cast coned drum, 9 to 12 feet in diameter, carrying 1 ⅜-inch steel rope. These engines had been previously hoisting five cars, weighing about 4 tons each when loaded." E. G.

ELECTRICITY IN MINING.—Holt. *Trans. Am. Inst. Min. Eng.*, October, 1891. The hoist is a 7½ horse power street car motor, manufactured by the Sprague Electric Railway and Motor Company. The motor, by engaging with a second drum, draws the empty cars in the tunnel by a tail-rope system, the loaded train running out by gravity. This motor proved the success of the plant from the start, notwithstanding the trying conditions under which it was at first used—one of which was the great amount of moisture in the workings, which condensed upon the machine. Later, the iron pinions on the armature-shaft were exchanged for raw-hide pinions, diminishing the noise when running, and also the liability of any leakage of current to the levers and other parts of the machinery. The working of this motor was so successful that during the same year another similar hoist was introduced. Each of these hoisters was designed to raise 250 tons 250 feet up a 60° incline every 24 hours, estimating 16 hours of actual working time.

The first motor has been in constant use for hoisting for 3 years, during which time the cost of repairs has been as follows:

| | |
|---|---|
| (*a*) Re-placing field-magnet coils, . . . . . | $43.00 |
| (*b*) Re-winding one armature, . . . . . | 80.00 |
| (*c*) Replacing commutators, . . . . . | 75.00 |
| Total repairs, . . . . . | $198.00 |

*a*, Burning out of insulation on wires of magnet coils.
*b*, Bursting of binding wires on armatures.
*c*, Due to use of Arc brushes. Carbon now used. No sparking and less wear.

Recently finding that the 7 1-2 horse power hoist at the head of one of the inclines was getting too small for the work required, it was removed and a 25 horse-power C. & C. electric motor put in its place. This larger moter is geared so as to raise a load of 3000 pounds up 60° incline 275 feet per minute. It is capable, by actual timing, of making the round trip from a depth of 550 feet with a load of 3000 pounds, in 3 minutes.

In July, 1890, the Company received from the Sullivan Diamond Prospecting Company, of Chicago, an electric prospecting-drill. It is operated by a 3 horse-power Thomson-Houston motor, and has a capacity of 400 feet, taking out a core $\frac{1}{1\frac{5}{8}}$ of an inch in diameter. The average per shift, allowing for time lost in moving, setting up and drawing cores, is 15 feet, one drill-man and one helper being employed. About 4400 feet have been drilled to date of writing, July 6, 1891. The exact cost, including all expenses, has been 68 cents per foot. This is rather higher than was expected, and it is thought that it can be reduced.

*Cost of Generating.*—The cost of generating, as obtained by dividing the cost of labor and lubricants (interest and depreciation are not included) by the horse-power demanded, amounts at present to

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two-thirds of one cent per horse power per hour; and greater amounts of power could be furnished at a lower rate per horse-power, as up to 100-horse-power no increase of plant would be necessary. The cost for labor would remain the same, and the cost of lubricants would advance but little.

The plant has a capacity of 100 electrical horse-power, which is generated by two 50-horse-power Thomson-Houston motor-type dynamos, wound for a constant potential of 500 volts. These are run from two double Pelton water-wheels, 42 inches in diameter. This current has not been found fatal so far, though several men have received shocks.

*Wiring.*—Power station to tunnel, 6000 feet, are bare copper wire, except 300 feet on each end which is insulated. Loss 5 to 6 per cent. when carrying maximum load. Inside 1000 feet, Kerite seven-strand conductors having heavy insulation, $\frac{14}{32}$ inch in diameter, loss less than 5 per cent. E. G.

ELECTRIC MOTORS IN GERMAN MINES. Eilers (*Am. Inst. Min. Eng.*, Oct., 1891).

During two years Eilers heard of only four electric mine-locomotive plants; three Siemens-Halske, one Allgemeine Elektrititäts Gesellshaft.

Of the installation at the Hohenzollern Grube, which will, perhaps, serve best as a type of those built by Siemens and Halske, I am able through the kindness of Inspector Kraski, in Beuthen, to present some sketches. At this mine there are at present two lines on which electric locomotives run. Each has its own locomotive, and each locomotive has had till recently its special dynamo above ground.

These dynamos the company has now replaced with two others of a newer type ($^{p}$H19) of 60 horse-power each, and yielding 140 ampères at 300 volts. Only one of these is kept in use; the other being held in reserve.

At present, the current is transmitted through the shaft by two cables for each locomotive. These consist of a core of rubber with 19 copper wires tinned and wound with impregnated hemp, the whole being protected by 13 pieces of galvanized iron wire. 2½ mm. thick.

This cable is fastened to the shaft-wall with iron hooks, immediate contact between cable and hook being prevented by supporting the former at the point of support with a layer of wood or asbestos. In this way the loss of electricity is reduced to a minimum; formerly, when using a cable with a hard covering in immediate contact with the iron hooks, great loss of current was caused by the destruction of the covering and insulation.

The cables, 220 meters long, carry the current to the ⊥-irons that serve as contact-rails. From these it is transmitted to the motor by a contact sled.

The single lengths of ⊥-iron are fastened together with plates bolted and soldered to the ends to be joined.

When the "sled" was first introduced, an attempt was made to lessen its friction by providing on the frame oil-boxes, which were to keep the contact-rail well lubricated. It was found, however, that the oil oxidized very rapidly, and then the ⊥-rails soon became, contrary to all desire, excellently insulated. The contact-sleds are therefore now made without oiling arrangements.

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From the middle of each of the sleds a hemp rope runs down to the locomotive. Its purpose is to drag the sled while serving also as a centre about which the conducting cables are wound, loosely, so as to be relieved from all strain.

Inspector Kraski, proposes the use of an extra brake on the armature shaft, in order to lessen the starting shock.

From the brushes the current passes through a switch-board, etc., and thence in cables, down the shaft in the gangways. One of the cables is connected with the rail, the other with the overhead conductor, which consists of two strips of band iron riveted together, or strips of small profile iron.

It is very easy to arrange for a switch with this conductor, by simply riveting a branch to the main conductor wherever there is a switch in the track.

Two springs fastened to the top of the locomotive press a solid block of metal against the band iron from below, and so allow the electricity to enter the locomotive. There the current is divided, part going to excite the magnets and part flowing through the armature. The motor is shunt-wound, like the dynamo, and the brushes of the motor, like those of the dynamo, are of gas-carbon. Return current through rail to dynamo.

| | |
|---|---|
| Ratio of cost of electric power to man power, . . . | 40 : 100. |
| To horses, . . . . . | 71 : 100. |

All mines using electric power described are coal mines, but not fiery.

---

The following values for the electrical units will probably be universally and finally adopted. F. B. CROCKER.

ABSTRACT FROM THE REPORT OF THE COMMITTEE ON ELECTRICAL STANDARDS APPOINTED BY THE BOARD OF TRADE, ENGLAND.

*Ohm.* = "Resistance offered to an unvarying electric current by a column of mercury of a constant cross-sectional area of 1 square mm. and of a length of 106.3 cm. at the temperature of melting ice.

*B. A.* "Unit = .9866 new ohm.

"A material standard, constructed in solid metal and verified by comparison with the B. A. unit, should be adopted as the standard ohm.

*Ampere.* = "An unvarying current, which when passed through a solution of nitrate of silver in water in accordance with the specifications attached to this report, deposits silver at the rate of .001118 grm. per second."

"An alternating current of one ampere shall mean a current such that the square root of the time average of the square of its strength at each instant in amperes is unity." Instruments constructed on the principle of the balance (in which the electro-dynamic attraction and repulsion between conductors is balanced by known weights) should be adopted as standards for the measurement of current whether unvarying or alternating.

*Volt.*—The electrical pressure at a temperature of 62° F. between the poles or electrodes of the voltaic cell known as Clark's cell, may be taken as not differing from a pressure of 1.433 volts, by more than an amount which will be determined by a sub-committee appointed to

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investigate the question, who will prepare a specification for the construction and use of the cell.

"An alternating pressure of one volt shall mean a pressure such that the square root of the time average of the square of its value at each instant in volts is unity."

Instruments constructed on the principle of Sir W. Thomson's quadrant electrometer used idiostatically and for high pressure instruments on the principle of the balance (electrostatic forces being balanced by known weights) should be adopted as standards for the measurement of pressure, whether unvarying or alternating.

The specification referred to in the definition of the ampere is as follows:

"In employing the silver voltameter to measure currents of about 1 ampere the following arrangement should be adopted: The kathode on which the silver is to be deposited should be a platinum bowl not less than 10 cm. in diameter, and from 4 to 5 cm. in depth.

"The anode should be a plate of pure silver some 30 square cm. in area and 2 or 3 mm. in thickness.

"This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners. To prevent the disintegrated silver from the anode from falling on the kathode, the anode should be wrapped around with pure filter paper secured at the back with sealing wax. Use a neutral solution of 15 parts by weight of pure silver nitrate to 85 parts of water.

"The resistance of the voltameter changes somewhat. To prevent these changes having too great an effect on the current, some resistance not less than 10 ohms besides that of the voltameter, should be inserted in the circuit."

The platinum bowl is washed with nitric acid and distilled water; dried by heat, cooled in a desiccator and weighed carefully. It is nearly filled with the solution and connected to the circuit by being placed on a clean, insulated copper support, to which a binding screw is attached.

"The anode is then immersed in the solution so as to be well covered by it and supported in that position. The connections to the rest of the circuit are made."

"Contact is made at the key, noting the time of contact. The current is allowed to pass for not less than half an hour and the time at which the contact is broken is observed." The interval must be accurately timed. "The solution is now removed from the bowl and the deposit washed with distilled water and left to soak for at least six hours." It is then rinsed successively with distilled water and absolute alcohol and dried in an air bath at 150° C. "After cooling in a desiccator it is weighed again. The gain in weight gives the silver deposited.

"To find the current in amperes, this weight (gain) expressed in grammes, is divided by the number of seconds during which the current has been passed, and by 001118." The result is the time average of the current, if the current has been varied. "In determining by this method the constant of an instrument the current should be kept as nearly constant as possible, and readings of the instrument taken frequently." This gives a curve from which the mean (time average of) current may be found.

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# BOOK REVIEWS.

THE PHOSPHATES OF AMERICA. Where and how they occur, how they are mined, and what they cost. With practical treatises on the manufacture of sulphuric acid, acid phosphate, phosphoric acid, and concentrated superphosphates, and selected methods of chemical analysis. By Francis Wyatt, Ph.D. Second edition. The Scientific Publishing Co., 27 Park Place, New York: 1891. 8vo. 187 pp.

The fact that the preparation of a second edition of this book became necessary within a week after the publication of the first, is a matter upon which the publishers congratulate themselves in their preface to this edition. Certainly the interest in the phosphate deposits of our continent has been recently much stimulated, and the book before us has met a desire on the part of many to have collected in one volume some general information with regard to those deposits. The work has been fairly well done, though throughout it is strongly tinged with the individuality of the writer, who has been unable to refrain from giving along with the facts his own special and decided views on many of the points brought up. Unfortunately, though provided with a good index, a table of contents, showing the plan and scope of the work, has been omitted.

The first chapter treats of general matters, such as the connection between the composition of soils and of the plants which grow upon them. The relation of the mechanical texture of the soil to its fertility is, we think, hardly given the prominence which it deserves. The statistics of the production of cereals, etc., in the United States are given. The author estimates that in the cereal crop our farmers remove annually from the soil under such cultivation 19 pounds of phosphoric acid per acre. The corresponding figure for the hay crop is put at 12.5 pounds phosphoric acid per acre.

Chapter II. deals with phosphates in general, with a brief account of the views entertained as to the nature and functions of fertilizers previous to Boussingault's demonstration of the necessity for phosphates in the development of plants. A table showing the average composition of the output of most of the important phosphate deposits elsewhere than in North America, is given. The value of iron and alumina phosphates as fertilizers is asserted, and the question of assimilability of different phosphates is discussed. In this connection the custom still prevailing in England and some parts of Germany of basing the commercial value of a phosphate almost entirely upon the percentage of "water soluble" phosphoric acid, is justly condemned.

Chapter III. treats of the Canada phosphate deposits (first worked in 1863), and describes as a typical mine the "North Star mine." The diverse theories as to the origin of these deposits is discussed. The ratio of apatite to other minerals in them is put at 7 per cent. The average cost of mining per ton (including interest on capital, etc,) is put at $10. The comparative inaccessibility of most of the deposits, and the consequent cost of transportation, hampers their development. The statistics for the last twelve years shows on the whole a progressive

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increase in output, though the amount of output and the prices realized show great irregularities. The first grades contain on the average over 88 per cent. of calcium phosphate which sells for $25, or over, per ton.

Chapter IV. is devoted to the South Carolina phosphate beds, which were discovered in 1845, but were not worked until 1867. The area covered by these is a tract about 70 miles in length by about 30 miles in width. No exploitations have extended below 15 feet in depth. The author estimates that this supply will be exhausted in about 28 years. The average cost of extracting and preparing the "River" phosphate for market is put at $3.50 per ton, and the selling price of a 57 per cent. phosphate at twice this figure. The land rock contains on an average nearly 60 per cent. of phosphate. The statistics given show a steady increase in the annual output—from nearly 20,000 tons in 1868–70 to over 537,000 tons in 1890.

In Chapter V. we find a description of the deposits which of late have excited the most interest, those of Florida. Here the first operations were in 1888. The lack of capital for the exploitation of these deposits, and the apparently capricious quality of many portions, are at present obstacles in the way of their development. The probable origin of these deposits is discussed. Apparently the data thus far obtained are insufficient for a satisfactory decision.

Chapter VI. describes the method of manufacturing sulphuric acid. The author unhesitatingly advocates the use of pyrites instead of brimstone as the raw material. A table of the average composition of pyrites from various sources is given.

Chapter VII. discusses the manufacture of superphosphates ("supers," as the author terms them). The results of some manufacturing experiments are detailed as showing the advantages of the presence of calcium carbonate in handling certain phosphates. The formulæ (chemical and manufacturing) are given. Grinding mills and mixers are also discussed. A description is also given of the process (more common in Europe than here) of making "high grade superphosphates" containing 45 per cent of soluble phosphoric acid, instead of 12 or 14, as in ordinary superphosphates, phosphoric acid instead of sulphuric acid being made to act upon the ground rock. This method of manufacture is strongly advocated. For the condensation of fumes from the mixers containing fluorine compounds, the author recommends scrubbers containing wooden spars as preferable to those filled with fire-brick.

In the last chapter (VIII.) are given methods of analysis of raw phosphates, superphosphates, pyrites, etc. In this chapter, as also elsewhere, the discrepancies between the results obtained by different chemists on the same lots are spoken of, and the comments are, in effect, that if the analysts will not lay aside their self-sufficient attitude and come to some agreement as to methods of analysis, the mine owners must. The author is unfair to the analysts in blaming them to the extent which he does, for these discrepancies, since we have good reason to believe that faulty sampling and matters of the kind, usually beyond the analysts' control, are more frequently at the bottom of them.

While adopting some of the methods and directions laid down by the Association of Official Agricultural Chemists, that organization is not mentioned, and he ignores entirely the labors of that society in this direction (agreement as to methods of analysis) and the advantages

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which have resulted therefrom. We will venture to predict that the methods of his own, which he gives, if followed conscientiously from his book by a dozen experienced analysts, would show results in several respects more widely at variance than the discrepancies which he quotes.

The mode of calculating and combining the constituents determined in the analysis of a phosphate rock is prescribed essentially as follows:

| | |
|---|---|
| MgO, | $\times 2.1 = Mg\,CO_3$ |
| Surplus $CO_2$, | $\times 2.27 = Ca\,CO_3$ |
| Fl, | $\times 2.05 = CaF_2$ |
| $SO_3$. | $\times 0.75 = FeS_2$ (Pyrites) |
| Surplus Ca, | $\times 1\,84 = Ca_3(PO_4)_2$ |
| Surplus $P_2O_5$, | $\times 2 = (FeAl)_2(PO_4)_2$ |

The remaining iron and aluminum oxides (if any) are to be attributed to clay. A series of tables, directions for the preparation of standard solutions, list of apparatus and chemicals for the outfit of a "phosphate mining" or "fertilizing factory," laboratory, etc., finishes the chapter and the book. The table of atomic weights [masses?] stated to be "according to the latest determinations," differs in many respects from those given in Prof. Clarke's latest revised table. A few cases may be quoted for comparison.

| | Wyatt. | Clarke. |
|---|---|---|
| Hydrogen, | 1 | 1.007 |
| Oxygen, | 15.96 | 16.00 |
| Antimony, | 122 | 120 |
| Calcium, | 39.9 | 40 |
| Lead, | 206.4 | 206.95 |
| Magnesium, | 23.94 | 24.3 |
| Phosphorus, | 30.96 | 31 |
| Platinum, | 196.7 | 195 |
| Silver, | 107.66 | 107.92 |
| Zinc, | 64.9 | 65.3 |

On the whole, notwithstanding some defects, the book affords much valuable and interesting information. E. WALLER, Ph. D.

---

METHODS OF GAS ANALYSIS. By Dr. Walther Hempel; translated from the second German edition by G. M. Dennis. Macmillan & Co., London and New York. 1892.

This 8vo. book of 368 pages in clear and clean type, with 101 fine quality illustrations has just appeared, meeting better than any other work in English of like nature, a desideratum which workers in gas analysis processes have long recognized. The matter of this volume bears evidence of years of painstaking laboratory experimenting, and of careful examination of the works of contemporaneous laborers in this field of analysis. Though the principles of the gas methods for the greater part are not new, yet this book, in accord with the pressing needs of our rapidly developing industries, is quite rich in new devices of apparatus, tending towards refining pre-existing rapid approximate, and rapid exact methods.

To those not yet greatly experienced in general chemistry and gas

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work this book will be a great aid, because of its clear exposition (barring a few instances of obscure description and meaning), and because of its giving consecutive details for the analysis of illuminating gas, air, furnace, and mine gases, and because further, of giving up to date standard methods of determining important constituents of complex industry gases. The Hempel modification of Berthelot's calorimeter for determining the calorific power of coals; the article on the analysis of nitrogenous organic substances (for nitrogen), combining combustion-tube, Töpler pump, and Hempel mercury bath; and also the article on determination of the candle power of illuminating gas, add much value to the volume.

The book consists of three parts: I. General Methods (?) which is really only a description of apparatuses and how to manipulate them; II. Special Methods (?) which in general gives the chemical properties of various gases; and III. Practical Applications of Gas Analysis. It is thus seen that this book is not designed to aid one particularly in the study of the properties of different gases (absorption, diffusion, specific heat, etc.), but that its aim is rather to meet technological wants by rapid and yet reasonably accurate results. The apparatus described in this work, being quite fragile and costly, require deft manipulation, which facts have prompted others to modify some of them, thereby exchanging expense in apparatus for somewhat lessened accuracy of results. This contribution to gas analysis literature cannot fail to be acceptable to all interested in gas examinations.

H. C. B.

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MODERN AMERICAN METHODS OF COPPER SMELTING. By E D. Peters, Jr., M.E., M.D. Second Edition. Colth binding. 400 pp. Illustrated. Published by Scientific Publishing Company, N. Y., 1891.

The first edition of this work appeared in 1887 and received very favorable mention from the leading metallurgists of the country. The appearance of the second edition was so well received that it was practically exhausted before it left the press. A third edition is now in preparation, if not already in the market.

This volume is about one-third larger than the first edition; it is of good quality paper and typography; many of the illustrations are from actual working drawings of furnaces, and particular attention is called to the detailed descriptions and drawings of the latest improvements in the reverberatory furnaces for copper, in one case nine drawings of the large type of modern reverberating furnace are given, which constitute probably the most complete set yet published. In addition to enlarging and revising the first edition, Dr. Peters has added special chapters on the electrolytic assay of copper, the smelting of pyritiferous copper-ores containing nickel, and the refining of copper by gas in Sweden.

The table of contents is as follows, viz.: Chapter I.—Description of the Ores of Copper; Chapter II.—Distribution of the Ores of Copper; Chapter III.—Methods of Copper Assaying; Chapter IV.—The Roasting of Ores in Lump Form; Chapter V.—Stall Roasting; Chapter VI.—The Roasting of Ores in Lump Form in Kilns; Chapter VII.—Calcination of Ores and Matte in Finely Divided Condition; Chapter

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VIII.—The Chemistry of the Calcining Process; Chapter IX.—The Smelting of Copper; Chapter X.—Blast-Furnaces Constructed of Brick; Chapter XI.—General Remarks on Blast-Furnace Smelting; Chapter XII.—Late Improvements in Blast Furnaces; Chapter XIII.—The Smelting of Pyritous Ores Containing Copper and Nickel; Chapter XIV.—Reverberatory Furnaces; Chapter XV.—Refining Copper by Gas in Sweden; Chapter XVI.—Treatment of Gold and Silver Bearing Copper-Ores; Chapter XVII.—The Bessemerizing of Copper Matte.

This valuable work may be highly recommended to those interested in the metallurgy of copper, whether they are practical workers or engaged in teaching the subject, and the evidence of the appreciation of Dr. Peters' admirable work is fittingly shown in the rapid exhaustion of this edition. J. S.

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# BULLETIN OF ALUMNI AND COLLEGE NEWS.

## Department of Engineering.

An undergraduate course of four years in Electrical Engineering has been established in the School of Mines, Columbia College, in addition to the present two year post-graduate course which has been in successful operation for several years. Thus there will be two complete courses in Electrical Engineering at Columbia.

The latter course is for graduates of Scientific Schools and Colleges, and is entirely devoted to Electrical Engineering proper, the students having already passed the necessary preparatory studies in Mathematics, Physics, Chemistry, Mechanics, Drawing, etc. This course is found to give the most excellent results by reason of the mature years and previous training of post-graduate students.

In addition to such graduate students there are, of course, a large number of young men who wish to enter a course of electrical engineering immediately on leaving school, without going through a previous collegiate course.

A new four year course has therefore been established parallel to the regular courses in Mining Engineering, Civil Engineering, Chemistry, Architecture, etc., at the School of Mines, with the same requirements for admission which are substantially equal to the regular entrance examinations at first-class scientific schools.

The first two years of the new course will cover the preparatory work in Mathematics, Physics, etc., required for admission to the post-graduate course. The last two years will be devoted to a thorough course in Electrical Engineering proper and will be equivalent to the present post-graduate course, hence there is no lowering of standard.

The instruction in Electrical Engineering will be conducted as heretofore by Prof. Crocker and Dr. Pupin.

The Mathematics, Physics, etc., will be taught by the respective professors of those subjects.

The degree given to those who satisfactorily complete the course will be that of Electrical Engineer. The new course will regularly begin October, 1892. Examinations for entrance are held in June and September.

The one year partial or special course will be abolished next year to make room for the students in the regular courses.

The complete list of studies required in the new course is as follows:

### FIRST YEAR.

*First Session.*—Trigonometry; Physics (Heat, Sound); Chemistry; Qualitative Analysis; Drawing.

*Second Session.*—Algebra; Analytical Geometry; Graphics; Physics (Magnetism, Electricity, Light); Chemistry; Qualitative Analysis; Drawing.

Summer vacation.

Memoir.

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SECOND YEAR.

*First Session.*—Analytical Geometry; Calculus; Graphics; Hygiene; Applied Chemistry; Physical Laboratory; Drawing.

*Second Session.*—Calculus; Hygiene; Applied Chemistry; Elements of Electrical Engineering; Physical Laboratory; Drawing.

Summer vacation.

Memoir.

THIRD YEAR.

*First Session.*—Analytical Mechanics; Physics (Theory of Heat, Electricity); Engineering; Properties of Materials; Dynamo and Motor (Practical); Theory of Dynamo and Motor; Electrical Measurements; Electrical Engineering Laboratory; Drawing (Designs).

*Second Session.*—Analytical Mechanics; Physics (Electricity); Engineering; Properties of Materials; Electric Lighting; Theory of Dynamo and Motor; Electrical Measurements; Electrical Engineering Laboratory; Drawing (Designs).

Summer vacation.

Memoir.

FOURTH YEAR.

*First Session.*—Dynamics of Machinery; Heat and its Applications; Machinery and Mill Work: Mechanical Engineering; Engineering Design; Electric Power; Theory of Dynamo and Motor (Advanced); Electrical Engineering Laboratory; Drawing (Constructions).

*Second Session.*—Dynamics of Machinery; Heat and its Applications; Machinery and Mill Work; Mechanical Engineering; Engineering Design; Telegraph and Telephone (Advanced); Theory of Electricity (Advanced); Electrical Engineering Laboratory; Drawing (Constructions); Thesis.

DEPARTMENT OF MINERALOGY AND METALLURGY.

The mineralogical collection has received a number of additions from collections made by Dr. Egleston in Japan during the past summer, which have been presented to the School.

These are a crystal of Topaz, which is 4 inches long, and in its macro-diagonal 4¾ inches and in its brachi-diagonal is 3½ inches wide. It shows a series of domes and pyramids which are very interesting. This is probably the finest crystal of Topaz which has ever come to this country. It was presented to the School by Mr. D. S. Plume, of Thomaston, Conn.

There is also a collection of 150 crystals of Topaz, illustrating its occurrence in Japan, many of them being 2 inches long by 1½ wide, showing a very large number of domes and pyramids and prisms. In addition to these there are a large number of crystals showing the methods of growth of Topaz and other curious phenomena connected with its formation. Besides these there are 8 Topazes cut as gems, which are most beautiful specimens. This is probably the finest collection of Japanese Topazes that has ever come to this country, and was presented to the School by Mr. William Schermerhorn of this city.

As a result of a visit to the Antimony Mines at Saijo, there is a beautiful collection consisting of pieces weighing over 50 pounds and of



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crystals 13 and 14 inches long and from 1 to 2 inches across and beautifully terminated, with 7 large pieces of Jade, 5 crystal balls, showing a great many interesting phenomena in quartz, and a collection of 6 balls in every stage of manufacture, with all the tools with which they are made; a carnelian box and two chalcedony cups used in feasts. This collection was presented by Mr. James Garland, of New York.

In addition to these were some blue Opals and crystals of quartz, 14 inches long, with very acute rhombohedra, which were presented by Mr. H. M. Cole of the class of 1887.

The Department has also received a very large number of minerals from other localities, most of which have been acquired by purchase.

The third edition of the Catalogue of Minerals has also been prepared and the plates are being corrected for the press.

A mineralogical laboratory has been fitted up in the old President's building, with three diamond saws and two lathes for cutting and polishing sections and all the appliances and fixtures for making measurements and other physical and optical investigations in the department of mineralogy. Two collections of over 130 of the finest rock and mineral sections made in Europe have also been purchased.

The Metallurgical collection has also received a number of additions to its models, notably a Japanese Piston-Bellows, and models of Blast Furnaces and Chimneys.

The collection of diagrams has been increased by 101 drawings made by the same artist who had made so many of the diagrams of the colection. 114 slides have also been added to the collection of slides.

The metallurgical collection has received 122 editions in various departments, some of the most notable of which are a collection of 13 very thin cast-iron rice-pans, cast in Japan, and a beautiful head of the mineralogist Kotcheroff, made in the Ural mountains, and presented by Mr. George F. Kuntz, of Tiffany & Co., which is a beautiful specimen of art.

Two Pelton water wheels to illustrate the lectures on hydraulic mining have boen presented by the Pelton Water Wheel Company.

Two Cornish Vanner Shovels have also been presented to the collection by Dr. Pearce, of the Boston and Colorado Works, Denver.

A collection of metallurgical specimens is being made to illustrate the lectures and is already of considerable size.

It is very seldom that both the Departments have to report such progress as has been made during the last three or four months.

It is greatly to be regretted that, on account of its being impossible to raise the money, a large part of the collections made by Dr. Egleston in Japan had to be sold.

## Department of Physics.

In the Physical Laboratory during the past term the third year class in the School of Mines has been occupied with the introductory experiments in Physical Measurement. The first term's work includes the various methods of measuring small distances, the construction and use of scales, the calibration of apparatus, the determination of errors of observation and of method, with applications in Mechanics, Sound,

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Heat and Light. The work of the second term is divided between Spectrum Analysis and Electrical and Magnetic Measurements.

The Laboratory has been open from 10 o'clock in the morning until 5 o'clock in the afternoon, for the use of students, and the hours of attendance have been arranged to suit their covenience.

In addition to the third year class of the School of Mines, a portion of the Senior Class of the Academic Department, as well as several special students have taken advantage of the opportunities offered by the Laboratory.

Research work is being carried forward by every one connected with the department, from the Professor down to the latest candidate for a Master's degree.

During the last six months important additions have been made to the stock of apparatus used in the Laboratory.

DEPARTMENT OF ASTRONOMY.

School of Mines men will be glad to learn that the College Observatory is to take part in the observations now in progress for determining the recently discovered variation of terrestrial latitudes. Some nine years ago, Fergola, the director of the Italian National Observatory, near Naples, pointed out that if a real motion of the terrestrial pole exists, it can best be determined by simultaneous observations at two observatories differing widely in longitude. He also showed that the highest accuracy would be secured if the observatories were situated upon nearly the same parallel of latitude. At the Rome meeting of the International Geodetic Congress (1883), he instanced the observatories of Columbia College and Naples as suitable for the purpose in question. The difference of latitude is only about six minutes of arc, while the longitudes differ almost ninety degrees.

Recently the Trustees have provided means for obtaining a special instrument suitable for this rather delicate investigation, and we are informed that the Italian government will, in all probability, at once order an instrument exactly similar to that now being constructed for the College. Thus the corresponding observations will be rendered simultaneous in date, precisely similar in form, and intercomparable, so that the maximum of accuracy may confidently be expected. Both instruments are to be made in Berlin. H. J.

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A

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APRIL, 1892.

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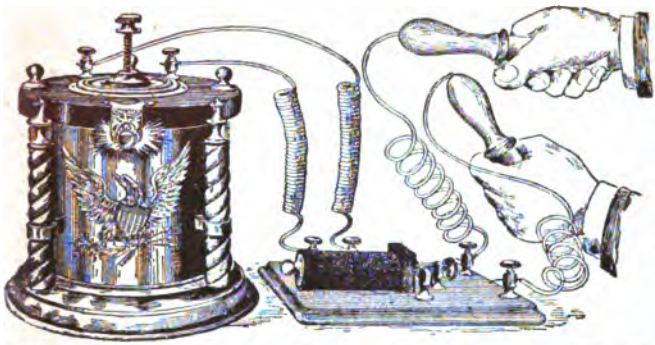

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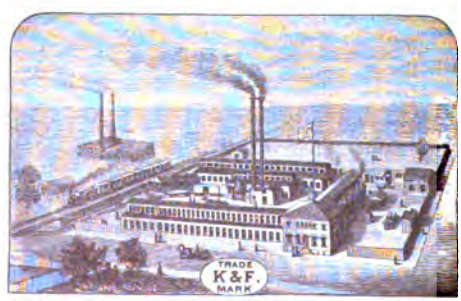


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VOL. XIII. APRIL, 1892. No. 3.

## SUCROSE, DEXTROSE, LEVULOSE:

### THEIR QUANTITATIVE DETERMINATION WHEN OCCURRING TOGETHER.

BY F. G. WIECHMANN, PH.D.

AN accurate method for the determination of sucrose, dextrose and levulose, when occurring together, has long been sought for in sugar-chemistry, for such a method of analysis would prove valuable for the solution of many questions of interest and importance.

The solving of this problem, a problem of acknowledged difficulty,* has been attempted by different workers and in various ways.

For some years past it has also engaged the attention of the writer, and in the SCHOOL OF MINES QUARTERLY, Columbia College, New York,† are given some of his former studies on this subject.

The method of analysis there described, a method based solely on gravimetric determination, yet awaits, in order to furnish results

* Thus, B. Tollens: *Kurzes Handbuch der Kohlenhydrate*, p. 90: "Sehr schwierig ist die Bestimmung, wenn Gemenge von Lävulose mit anderen Glycosen wie Dextrose oder mit Rohrzucker vorliegen."

† Vol. xi., No. 3, vol. xii., No. 3.



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reliable under all circumstances, discovery of some agent whereby the complete destruction of either the dextrose or the levulose may be accomplished, while the sugar not destroyed, shall remain entirely unchanged in its properties.

As the chances for immediate success in this direction did not seem very promising, the solution of the tempting problem was sought, and found in another manner.

In recording in this paper the successful outcome of his quest, the writer desires to acknowledge his obligations to those who before him have attempted this task, and a critical study of whose labors has proved of value to the writer in his own researches. Furthermore, his sincere thanks are due his assistant, Mr. E. C. Brainerd, for much valuable work most carefully and conscientiously performed in this investigation.

The method here to be described involves but three simple analytical operations: two gravimetric determinations, and one optical examination with the polariscope. The method is therefore easy and rapid of execution, and at the same time, with careful manipulation, yields most accurate results, as will appear from the various trials to which the method was subjected in order to determine its value and delicacy. A full record of these experiments follows the subjoined description of the method.

## THE METHOD.

*Preparation of Solution.*—If not already in solution, make of the sample to be examined a solution of arbitrary density. Of course, it goes without saying, that this method is to be applied only in cases where no other optically active substances are present besides sucrose, dextrose and levulose, and that care must be exercised that no preliminary treatment of the solution shall influence its original power of rotation.

The specific gravity of the solution above referred to is accurately determined by balance, and from this value there are calculated, in the following manner, the number of grammes of solution which contain 10.000 grammes of dry substance:*

Ascertain the degree Brix corresponding to the specific gravity found. Divide 100 by the degree Brix; the quotient represents

* This concentration is chosen because the specific rotary powers of the sugars, values needed in the calculation of results, vary with the concentration.

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the number of grammes of solution which contain 1.00 gramme of dry substance. This value is multiplied by 10, and the product represents the number of grammes of solution, equivalent to 10.000 grammes of dry substance.

This amount is weighed out, placed in an accurately graduated 100 c.c. flask, and the solution in the flask is made up to 100 c.c. with distilled water.

The determinations to be made, are as follows:

*Optical Examination.*—Some of the solution is placed in a water-jacketed polarization-tube, a thermometer is inserted in the solution, and a reading on this solution is taken in the polariscope, at the temperature of 20° C.

The reading thus obtained must be reduced to the basis of a reading made in a 100 m.m. tube.

Furthermore, if a sugar-polariscope has been used for the observation, the reading obtained must be transformed into circular degrees. With a polariscope using 26.048 grammes as the normal weight, the factor 0.346 is used, for the sodium ray.

*Gravimetric Determination Before Inversion.*—Of the 10 per cent. solution, weigh out an amount equivalent to 1.0 gramme of dry substance. Make this up to 150 c.c., and of this solution take 24.4 c.c., equivalent to 0 1628 gramme dry substance. Take 50 c.c. of Fehling's solution,* heat to boiling; while boiling add the 24.4 c.c. of sugar solution, and boil for three minutes.

Then remove from flame, add cold distilled water, previously boiled, in order to cool the solution and prevent a further deposition of cuprous oxide.

Filter through a weighed asbestos filter, wash first with boiling water, then with absolute ethyl alcohol, and finally with ether. Dry perfectly, cool and weigh.

Calculate the cuprous oxide to its equivalent of metallic copper, and from the copper thus found, ascertain the amount of sucrose corresponding.† From this figure the total reducing-sugars by adding $\frac{1}{20}$ to the sucrose value indicated.

*Gravimetric Determination after Inversion.*—Of the original 10 per cent. solution, weigh off an amount equal to 5.000 grammes dry

* Cupric sulphate cryst.: 34 639 grammes in 500 c.c. water; Rochelle salts, 173.000 grammes in 400 c.c. $H_2O$; Sodic hydrate, 50.000 grammes in 100 c.c. $H_2O$.

† Table published by the German Government, Law of 1887; also in Wiechmann, "Sugar Analysis," Table XI.

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substance; invert with 4 c.c. of concentrated HCl (specific gravity 1.20) by heating on boiling water bath up to a temperature of 67° C. and maintaining the solution at that temperature for five minutes. Then remove the flask, cool it and its contents to the temperature at which the flask was graduated, and then make the solution up to 100 c.c.

Of the solution thus obtained take 20 c.c. and neutralize with sodium carbonate; then make up to a volume of 150 c.c. with distilled water; of this solution take 24.4 c.c., equivalent to 0.1628 gramme of dry substance, and proceed precisely as previously directed. Determine the value found, as before, from the table; the result obtained represents the total sugars present, *expressed as sucrose*. From this amount subtract the *sucrose* value found by prior determination,* and the difference represents the amount of sucrose actually present.

The results thus obtained represent: the polarization, in a 10 per cent. solution, of the three sugars combined; the total reducing-sugars present; the amount of sucrose present.

In cases where the reducing sugars, *i.e.*, the dextrose and the levulose together, exceed in amount the sucrose present, the gravimetric determinations before and after inversion should preferably be made according to E. Meissl's method for the determination of invert-sugar.†

## Calculation of the Results of Analysis.

This can be accomplished by algebra, or by allegation.

### By Algebra.

Let:

a = amount of sucrose present.
b = amount of total reducing sugars present.
x = amount of dextrose present.
y = amount of levulose present.
s = the specific rotatory power of sucrose, divided by 100.
d = the specific rotatory power of dextrose, divided by 100.
l = the specific rotatory power of levulose, divided by 100.
p = polarization observed, expressed in circular degrees.

* That is, the amount as actually found by table, prior to the addition of $\frac{1}{10}$.

† *Zeitschrift des Vereines für Rübenzucker-industrie*, vol. xxix., p. 1034, and E. Wein: *Tabellen zur Quantitativen Bestimmung der Zuckerarten*, Table No. iv.

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Then

$$(as + xd) - yl = p.$$
$$(as + xd) = p + yl.$$
$$xd = p + yl - as.$$
$$x = \frac{p + yl - as.}{d}$$

Substituting this value of x in the equation

$$x + y = b$$

there results:

$$\frac{p + yl - as}{d} + y = b.$$
$$p + yl - as + yd = bd.$$
$$yl + yd = bd - p + as.$$
$$y(l + d) = bd - p + as.$$
$$y = \frac{bd - p + as}{l + d.}$$

As y represents the amount of levulose, y deducted from b will give at once the amount of dextrose. Or, if preferred, the value of x can also easily be calculated independently.

*Example:*

Sucrose = a = 8.50.
Total reducing sugars = b = 1.50.
Polarization, expressed in circular degrees = p = 5.6426.
Specific rotatory power of sucrose ÷ 100 = s = + 0.665.
Specific rotatory power of dextrose ÷ 100 = d = + 0.535.
Specific rotatory power of levulose ÷ 100 = l = — 0.819.
Dextrose present = x.
Levulose present = y.

$$(8.50 \times .665 + x \times .535) - (y \times .819) = 5.6426.$$
$$(8.50 \times .665 + x \times .535) = 5.6426 + (y \times .819).$$
$$.535\,x = 5.6426 + .819\,y - 5.6525.$$

$$(1). \quad x = \frac{-0.0099 + .819\,y.}{.535}$$

$$(2). \quad x + y = 1.50.$$

Substituting the value of x found in equation (1), in equation (2), there results:

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$$\frac{-0.0099 + .819\,y}{.535} + y = 1.50$$

$$-0.0099 + .819\,y = 0.8025.$$
$$1.354\,y = 0.8124.$$
$$y = 0.600.$$

| | |
|---|---|
| Total Reducing Sugars present, . . | = 1.50 |
| Levulose present, . . . . . | = 0.60 |
| Dextrose present, . . . . . | = 0.90 |

By Allegation.

*Example:*

Determinations made on a 10 per cent. solution.

| | Per cent. |
|---|---|
| Sucrose present, . . . . . | = 66.0 |
| Total Reducing Sugars present, . . | = 34.0 |
| Polarization observed, . . . . | = 2.8199 |
| Polarization due to the sucrose = 6.6 × 0.665, . . . . . | = 4.3890 |
| Difference due to the 3.40 per cent. Reducing Sugars, . . . . | = 1.5691 |

$$34 : 100 :: 1.5691 : x$$
$$156.91 \div 34 = -4.615.$$

$$\left.\begin{matrix} +53.5 \\ -81.9 \end{matrix}\right\rangle -46.15$$

35.75
99.65
135.40

135.4 : 35.75 :: 34 : x = 8.98 per cent of Dextrose.
135.4 : 99.65 :: 34 : y = 25.02 per cent. of Levulose.

Or else, having found the percentage of Dextrose as above,

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| | Per Cent. |
|---|---|
| Total Reducing Sugars, . . . . | = 34.00 |
| Dextrose present, . . . . . | = 8.98 |
| Levulose present, . . . . . | = 25.02 |

As to reporting the nature of the reducing sugars, the analysis of course only *warrants* the stating of the actual amounts of sucrose, of dextrose, and of levulose as found.

Should it, however be so desired, equal quantities of dextrose and levulose might be considered as present in the form of invert-sugar.

The dextrose or the levulose, of whichever one least is found, might be regarded as combined with an equal amount of the other, forming invert-sugar, and any excess over the amount so disposed of, could be reported as free, or uncombined dextrose, or levulose, as the case might be.

## Experimental Test of Method.

*Instruments Employed.*—The polariscope used was a half shade instrument of Scheibler's make; every degree of its scale had been tested with a control-tube of Schmidt and Hänsch.

The polarizations were all made with a Schmidt and Hänsch water-jacketed tube, 200 mm. long. The temperature of the solutions was determined by a small Centigrade thermometer graduated in tenths of a degree, made by the above firm, and of Jena normal glass. All readings in the polariscope were made by two observers; the observations were generally made every half degree Centigrade, from 17° to 20° C., but of course only the values obtained at 20° C. were placed on record.

*Materials Used in Experiments.*—The sucrose, the dextrose and the levulose used in the experiments were all prepared under the writer's direction.

The sucrose was made from the purest granulated sugar (polarization 99.9 — 100.0), by repeated washing with absolute ethyl-alcohol. A determination of the specific rotatory power of the sucrose in a 10 per cent. solution (10.0 grammes dry substance in 100 c.c.) gave $[a]_D^{20} = + 66.5$.

The dextrose was prepared from commercial anhydrous dex-

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trose by treatment with best blood-carbon and by repeated crystallization from absolute ethyl-alcohol.

A determination of the specific rotatory power of the dextrose in a 10 per cent. solution (10.0 grammes dry substance in 100 c.c.) gave $[a]_D^{20} = + 53.5$.

A determination of the reducing power of this material made by the method of J. Allihn, showed that 0.250 gramme dry substance of the dextrose reduced of metallic copper:

| | Gramme. |
|---|---|
| Determination 1, . . . . . | = 0.4655 |
| Determination 2, . . . . . | = 0.4663 |

In Allihn's table, 0.2499 gramme of dextrose corresponds to 0.4630 gramme Cu.

The levulose was prepared essentially according to the method of H. Ost,* from Inuline, prepared by H. Trommsdorff of Erfurt. 100.0 grammes of Inuline, 250.0 grammes of water, and 1.226 grammes of hydrochloric acid (specific gravity 1.20) were used. About three months after the work was commenced, and after being twice crystallized from absolute ethyl-alcohol, the levulose obtained was tested.

Duplicate determinations of the specific rotatory power of this specimen were made with all possible care, and it was found that in a 10 per cent solution (10.0 grammes dry substance in 100 c.c.) the value of $[a]_D^{20} = - 81.9$.

A determination of the reducing power of this material on copper solution was made by Allihn's method for dextrose, exactly as quoted by Hönig and Jesser† and this showed that 0.250 gramme of dry substance, reduced of metallic copper:

| | Gramme. |
|---|---|
| Determination No. 1, . . . . . | = 0.4319 |
| Determination No. 2, . . . . . | = 0.4309 |

Referring to Hönig and Jesser's investigation,‡ it will be seen, that they found 0.250 gramme of pure levulose reduced 0.428 Cu.

The $[a]_D^{20}$ value of this sample of levulose — 81.9 is identical

* *Zeitschrift für Analytische Chemie*, 1890, p. 648.

† *Zeitschrift des Vereines für Rübenzucker-industrie*, 1888, vol. 38, p. 1035.

‡ *Loc. cit.*

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with that quoted by Tollens* as obtained by calculation from data furnished by Dubrunfaut, Lescoeur and Morelle.

As the values for $[a]_D^{20}$ found by Tollens and others, differ greatly from this figure — 81.9 as well as from each other, there seems urgent need of an investigation to determine whether the specific rotatory power of levulose varies according to the source from which it is prepared, according to the method of its preparation, or possibly according to both.

In these experiments, of course, the value of l in the formula for calculating the results of the analyses, has been placed equal to — 0 819.

*Record of Experiments.*—In all, five series of tests were made. In the first series, dextrose and levulose only were used in order to study the behavior of these two sugars in the absence of sucrose and when mixed in different proportions. In the remaining four series, sucrose, dextrose and levulose were employed in varying proportions.

All polarizations were made on 10 per cent solutions (10.000 grammes dry substance, in 100 c.c.), at the temperature of 20° C. All polarizations were made, as before stated, in a sugar-polariscope and transformed into circular degrees by multiplying with 0.346.

The reliability of the gravimetric methods of determining the sucrose and the total reducing sugars having been amply demonstrated by a great number of experiments made at an earlier date, it was not deemed necessary to execute them in this work, and therefore the amounts of sucrose and of the total reducing sugars used in making the solutions, are assumed as having been determined by analysis.

To correctly appreciate the meaning of the results here recorded, it must be remembered that 1° on the scale of the sugar polariscope, in these observations, is equal to 0.346 circular degree. One-tenth of a degree on the sugar scale therefore corresponds to 0.0346 of a circular degree.

It will be granted, that it is impossible to make an observation on a sugar-scale which shall approximate closer to the truth than ± 0.1 of a degree. As this is equal to 0.0346 circular degree it will be but fair to regard all those observations made on the polariscope which come within these limits, viz.: ± 0.0346 of a circular degree, as theoretically correct.

* Kurzes *Handbuch der Kohlenhydrate, p.* 86.

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## Series I.

| Experiment. | 1. * | | |
|---|---|---|---|
| | Required. | Determined. | Difference. |
| Polarization in circular degrees..... | —0.0033 | 0.0000 | +0.0033 |
| Dextrose..... | 3.00 | 3.02 | +0.02 |
| Levulose..... | 2 00 | 1.98 | —0.02 |

## Series II.

| Experiment. | 1. | | |
|---|---|---|---|
| | Required. | Determined. | Difference. |
| Polarization in circular degrees..... | 6.2465 | 6.2909 | +0.0444 |
| Sucrose..... | 9.50 | ..... | ..... |
| Dextrose..... | 0.25 | 0.283 | +0.033 |
| Levulose..... | 0.25 | 0.217 | —0.033 |

## Series III.

| Experiment. | 1. | | |
|---|---|---|---|
| | Required. | Determined. | Difference. |
| Polarization in circular degrees..... | 5.4395 | 5.3922 | —0.0473 |
| Sucrose..... | 8.50 | ..... | ..... |
| Dextrose..... | 0.75 | 0.715 | —0.035 |
| Levulose..... | 0.75 | 0.785 | +0.035 |

## Series IV.

| Experiment. | 1. | | |
|---|---|---|---|
| | Required. | Determined. | Difference. |
| Polarization in circular degrees..... | 4.6325 | 4.5934 | —0.0391 |
| Sucrose..... | 7.50 | ..... | ..... |
| Dextrose..... | 1.25 | 1.221 | —0.029 |
| Levulose..... | 1.25 | 1.279 | +0.029 |

## Series V.

| Experiment. | 1. * | | |
|---|---|---|---|
| | Required. | Determined. | Difference. |
| Polarization in circular degrees..... | 3.8255 | 3.7945 | —0.0305 |
| Sucrose..... | 6.50 | ..... | ..... |
| Dextrose..... | 1.75 | 1.728 | —0.022 |
| Levulose..... | 1.75 | 1.772 | +0.022 |

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## SERIES I.

| 2. ° | | | 3. ° | | |
|---|---|---|---|---|---|
| Required. | Determined. | Difference. | Required. | Determined. | Difference. |
| —1.3870 | —1.3728 | —0 0142 | —0.7100 | —0.7036 | —0.0064 |
| 2.00 | 2.01 | +0.01 | 2.50 | 2.51 | +0.01 |
| 3.00 | 2.99 | —0.01 | 2.50 | 2.49 | —0.01 |

## SERIES II.

| 2. ° | | | 3. ° | | | 4. | | |
|---|---|---|---|---|---|---|---|---|
| Required. | Determined. | Difference. | Required. | Determined. | Difference. | Required. | Determined. | Difference. |
| 6.1788 | 6.1744 | —0.0044 | 6.3142 | 6.2909 | —0.0233 | 6.1918 | 6.2576 | +0.0658 |
| 9.50 | .... | ..... | 9.50 | ..... | ..... | 9.60 | ..... | ..... |
| 0.20 | 0.197 | —0.003 | 0.30 | 0.283 | —0.017 | 0.10 | 0.149 | +0.049 |
| 0.30 | 0.303 | +0.003 | 0.20 | 0.217 | +0.017 | 0.30 | 0.251 | —0.049 |

## SERIES III.

| 2. ° | | | 3. ° | | | 4. ° | | |
|---|---|---|---|---|---|---|---|---|
| Required. | Determined. | Difference. | Required. | Determined. | Difference. | Required. | Determined. | Difference. |
| 5.2364 | 5.2424 | +0.0060 | 5.6426 | 5.6418 | —0.0008 | 5.0463 | 5.0427 | —0.0036 |
| 8.50 | ... | ..... | 8.50 | ..... | ..... | 8.60 | ..... | ..... |
| 0.60 | 0.605 | +0.005 | 0.90 | 0.900 | 0.000 | 0 35 | 0.347 | —0.003 |
| 0.90 | 0.895 | —0.005 | 0.60 | 0.600 | 0.000 | 1.05 | 1 053 | +0.003 |

## SERIES IV.

| 2. ° | | | 3. ° | | | 4. | | |
|---|---|---|---|---|---|---|---|---|
| Required. | Determined. | Difference. | Required. | Determined. | Difference. | Required. | Determined. | Difference. |
| 4.2940 | 4.2938 | —0.0002 | 4.9710 | 4.9928 | +0.0218 | 3.9008 | 3.8611 | —0.0387 |
| 7.50 | ... | ..... | 7.50 | ..... | ..... | 7.60 | ..... | ..... |
| 1.00 | 1.000 | 0.000 | 1.50 | 1.517 | +0.017 | 0.60 | 0.571 | —0.029 |
| 1.50 | 1.500 | 0.000 | 1.00 | 0.983 | —0.017 | 1.80 | 1.829 | +0.029 |

## SERIES V.

| 2. ° | | | 3. ° | | | 4. | | |
|---|---|---|---|---|---|---|---|---|
| Required. | Determined. | Difference. | Required. | Determined. | Difference. | Required. | Determined. | Difference. |
| 3.3516 | 3.3285 | —0.0231 | 4.2994 | 4.3271 | +0.0277 | 2.7553 | 2.7127 | —0.0426 |
| 6.50 | ... | ..... | 6.50 | ..... | ..... | 6.60 | ..... | ..... |
| 1.40 | 1.383 | —0.017 | 2.10 | 2 121 | +0.021 | 0.85 | 0.819 | —0.031 |
| 2.10 | 2.117 | +0.017 | 1.40 | 1.379 | —0.021 | 2.55 | 2.581 | +0.031 |

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Making this allowance, inspection of the nineteen observations recorded in Series I. to V. inclusive, show, that of this number only six do not agree with the theoretical values. These exceptions are here given, and they exceed the limit of ± 0.0346 of a circular degree but slightly.

| Series. | No. | Amount of Difference. |
|---|---|---|
| II. | 1 | 0.0098 |
| II. | 4 | 0.0312 |
| III. | 1 | 0.0127 |
| IV. | 1 | 0.0045 |
| IV. | 4 | 0.0041 |
| V. | 4 | 0.0080 |

Five of these determinations are but very little outside of the limits assumed, and even the poorest of them all, Series II., No. 4, would come well within the limits, if ± 0.2 of a degree of the sugar polariscope be adopted as the range of variation in the readings. With a more finely graduated instrument much closer readings could of course be made.

The tables as given however show the amounts of levulose and of dextrose caculated from the polarizations *actually obtained*, and without making any allowance whatsoever.

All experiments marked with a star would have yielded the results theoretically required, that is to say, absolutely correct values, provided that ± 0.1 of a degree on the sugar polariscope had been allowed for variation in the readings; and if a range of ± 0.2 of a degree on the sugar polariscope had been allowed in taking the readings, *all experiments without exception* would have shown the analysis to have determined the amounts theoretically required.

For exact scientific investigations, for instance, for accurately determining the kind and amounts of these three sugars in sugar producing plants, at different stages of their growth, etc., a delicate and finely graduated polariscope is required, but the work here recorded bears ample evidence of the fact that this method can be employed to advantage with the facilities provided for in every well equipped sugar laboratory.

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# FORMULA FOR WATER POWER.

By PROF. W. P. TROWBRIDGE.

## Power of a Given Stream and Fall.

Let $H$ = actual fall from level of water, in penstock (or head race near the wheel) to level of water in the tail race at the wheel when wheel is running, which will be the available fall.

Let $E$ represent the efficiency of motor.

$W$ = the weight of water which flows in one minute through the wheel = $V \times 62.5$, the volume multiplied by the weight of a cubic foot of water. $H.\ P.$ = the horse power.

Then to find the quantity of water $V$ in cubic feet to give one horse power with one foot fall, we have the following expression:

$$V \times 62.5 \times E = 33{,}000.$$

$$V = \frac{33{,}000}{E \times 62.5} = 704 \text{ for an efficiency of } 75 \text{ per cent.}$$

That is, with a motor whose efficiency is 0.75, 704 cubic feet of water per minute falling one foot will give one horse power. For a fall of 10 feet the horse power will be 10, and for a fall of 20 feet the horse power will be 20, etc. And for a quantity of water falling equal to $n$ times 704 the horse power will be $n$ multiplied by the fall in feet. For example:

There is an available fall of 27.5 feet, and the average flow of water is 2200 cubic feet in a minute, the power of the stream will be

$$H.\ P. = 27.5 \times \frac{2200}{704} = 86.\ H.\ P.$$

To get the power of a stream multiply the available fall in feet by the average flow in cubic feet, divided by 704.

A very good general idea of the power of a waterfall may be expressed from the above by the following:

$$\overline{H.\ P.} = .00143 \times V \times H,$$

in which $V$ represents the total flow per minute in cubic feet, and $H$ the available fall in feet. This is a rough approximation and supposes the motor to have about 75 per cent. efficiency.

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# TOPOGRAPHICAL SURVEY OF THE STATE OF NEW YORK.

By PROF. W. P. TROWBRIDGE.

It is understood that the Board of Commissioners for the Survey of this State will make another effort during the present session of the Legislature to procure a small appropriation for beginning, in co-operation with the United States Geological Survey, the topographical survey of the State. The opportunity presented to the State is unusually favorable, because the United States Geological Survey will undertake to furnish all the surveyors and the instruments, and will do the work, including the engraving of the maps, provided the State will pay half the cost.

It is greatly to be desired that the efforts of the Board of Commissioners for the State Survey shall receive encouragement and support in their appeal to the Legislature, at this time, especially for the reason that the amount appropriated yearly by the Government to aid the States in making topographical surveys is limited; and just now the Director of the Geological Survey, having completed the surveys of States contiguous to New York, is prepared to put his full available force on the New York survey. A year hence it may happen that other States will ask for a share of this yearly appropriation, and it would have to be divided, thus causing slower progress in any one State.

The States of Massachusetts, Rhode Island, Connecticut and New Jersey have already availed themselves of this Governmental co-operation—complete topographical surveys of these States having recently been executed.

It is not to be supposed that the United States Government would make such favorable and liberal provisions for accurate topographical surveys of the States if Congress had not become convinced that such surveys are of national as well as of local importance. The State of New York is wonderfully diversified in its topographic features, and embraces within its limits magnificent rivers, lakes, mountains and forests. It is remarkable for the number of large cities and towns within its borders; for its numerous lines of traffic and commerce, both natural and artificial; and for

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its manufacturing and agricultural industries. In all these respects it stands unrivalled; and yet in many directions the progress of improvement and development is prevented and delayed for want of complete and accurate maps. This cannot be said of any other part of the civilized world where an equal area supports a corresponding intelligent population, and where similar conditions of commerce, manufacture and agriculture exist. When these conditions are found elsewhere, it will be found, also, that complete topographical surveys have been executed with all the accuracy attainable by scientific methods; and that maps made from these surveys have been printed and published at such a small cost as to make them available not only for public but private uses.

Of the maps of New York which are now sold by private publishers, whether they are wall-maps including the whole State, or maps of counties or towns, it may be said that they are compilations from old and inaccurate surveys, in which the magnetic compass—the most unreliable and misleading of all surveying instruments—was the chief, and generally the only reliance, as far as lines of direction were concerned; such surveys having been made from time to time, often by individuals having little knowledge or appreciation of exact processes, and without co-operation in design and execution on the part of the surveyors. The independent county and town maps made from these surveys with all their inaccuracies, have been fitted and matched together by a sort of forcing process to form a State map.

On the separate maps thus made many important topographical features are omitted altogether. Cross-roads are often left out. Minor streams are often omitted, or are represented in an imperfect way; and there is an absolute want of any representations on the maps of the elevations and depressions of the country; or at least if such representations occur they are drawn mostly from imagination and not from actual determinations. The maps are generally executed on paper with all the artistic care necessary to give them a pleasing appearance, but this only inspires a confidence in their accuracy which they do not merit. The publishers of existing maps deserve, nevertheless, much credit, for they have given us the only maps we possess. The inaccuracies and omissions are due to want of means and appliances, and the

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opportunities for employing exact and correct methods in making the surveys in the first instance.

In these respects New York is no better off than were the States above mentioned before the Government surveys were executed.

When the topographical map of Connecticut was begun, two years ago, by the United States Geological Survey, an effort was made to ascertain from published statements the approximate area of the State. Ten authorities were consulted, each differing from all the others—the greatest difference amounting to as much as three hundred square miles in less than five thousand square miles, which is the actual area taken from the late survey.

When the topographical surveys of England and Scotland were in progress it was found, among other inaccuracies, that a prominent headland on the northern coast was eleven miles out of position.

The survey of India disclosed the fact that the breadth of the Indian peninsula on the old maps differed by forty miles from its true breadth. Similar instances, though less conspicuous, might be given in the case of the survey of our own coast by the Coast Survey. In Massachusetts, Rhode Island and Connecticut, as in New York to-day, the old maps give no indications whatever by which the water-shed of a given stream can be determined. The most frequented roads are often incorrectely laid down; and to all appearances every road is on the same level throughout its whole length. A road may pass over mountains, sandy plains, or across marshes and swamps, but there is nothing to indicate these important features in its course.

It is only within three or four years that the variations of the magnetic needle in the different parts of the State of New York have been determined. The late reports of the Coast and Geodetic Survey show that the variation at the western boundary is now about four degrees west, and at the extreme northeastern limit of the State about fifteen degrees west, a progressive difference amounting to eleven degrees; moreover the lines along which the variations are the same are extremely irregular, and run in a general direction obliquely across the State from northwest to southeast.

The variations are moreover continually changing, so that variations for one year do not represent those for the next; and when we consider that a line run by the magnetic compass will be in error forty-six feet for every mile run, if there be an uncorrected

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variation of one degree, it may be readily seen what great errors must be committed in any survey depending on this instrument; and why it has been absolutely discarded in all surveys which are to constitute the basis of exact maps.

On this subject a few words quoted from the report of a Special Committee appointed by the American Geographical Society in 1875, to examine the existing maps of New York, furnish perhaps the most concise statement in regard to the inaccuracies of the maps.

This Committee reported, "that the maps were grossly inaccurate;" that the only surveys on which they rest are the old chain-and-compass surveys made through the woods nearly a hundred years ago for parcelling out tracts of land to settlers; and "that while the State of New York is the most populous and wealthy in the Union, the maps of the State are worse than those of almost any other commonwealth."

Later, and in some respects more significant, testimony in this respect is given in the report of Mr. O. H. Bogardus, to whom was assigned in 1878 the duty of determining and marking county boundaries.

This work was done under the supervision of the Director of the Trigonometrical Survey, Mr. James T. Gardner, and the report is to be found in the general report of the Board of Commissioners for the State Survey for 1887. Mr. Bogardus reported "that he had examined and marked by monuments about one hundred and fifty miles of county lines, one hundred of which follow along the lines of old grants." He states, "that it was impossible to establish any considerable portion from original marks; hence it is in the subsequent surveys as embodied in deeds bordering the lines that we find the only reliable data, and in the adjoining farm corners the monuments, from which to re-establish and verify the lines."

In commenting on this report Mr. O. S. Wilson, in charge of the triangulation by means of which the monuments were to be correctly located, states as follows: "Any one in reading Mr. Bogardus' report cannot fail to be impressed with the uncertainty of the political boundaries of the State as marked on the ground. Indeed, some of the county lines have never been so marked, especially where counties have been divided to form new ones. There is not a neighborhood in the settled portion of the State where



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there are not lines in dispute, and which can only be settled by having some starting point definitely fixed; as it is now, the greater the number of surveyors employed to run the lines the more confusion and uncertainty."

In the last remark Mr. Wilson evidently refers to the necessity of adopting for the State Survey the only methods which will insure accuracy—methods which have been practiced in every part of the civilized world, and for which there are no known or recognized substitutes.

These methods may be broadly separated into two distinct classes of operations, designated as trigonometrical surveys and topographical surveys. A trigonometrical survey is the indispensable preliminary work necessary for executing accurate topographical surveys. It consists in covering the whole area to be mapped with a network of triangles, the intersections of the lines being prominent landmarks, such as church spires, and signal poles placed on the summits of mountains and hills. The trigonometrical work consists in determining the exact lengths of all the lines of such a survey by suitable instruments and observations, so that the points which they connect may be plotted on a blank sheet of paper with such accuracy that the distance of any point to any other, near or remote, represents the true horizontal distance, with an error of only a few inches. A map or sheet on which there are plotted thousands of such controlling points in their true relative positions constitutes a sort of frame-work for the subsequent topographical survey. Such controlling points having been plotted on a sheet of paper, and the points connected by straight lines drawn with a pen, a network of lines will be formed which might be called a "trigonometrical" map, although the term "map" would perhaps be inappropriate. It would represent, however, a "trigonometrical survey," in which any distance on the map from one fixed point to another in any direction could be taken off by a scale with as much accuracy as the scale could be read. Distances along lines of triangulations between points two hundred miles apart have been found by the trigonometrical process to be in error less than one foot.

New York now possesses such a trigonometrical survey, extending over about two-thirds the area of the State. It was executed under the directions of the present Board of Commissioners, who incorporated, by permission, in their own work much that had been

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done for the purpose of the Lake surveys by the United States Government, and portions also of the triangulation of the United States Coast and Geodetic Survey, made for connecting the survey of the Coast with the Lake surveys.

For making maps useful to the community the next and final processes come under the head of "topographical surveys."

A topographical survey consists essentially in sketching in, or filling in, the surface of the paper on which the controlling points are plotted, by lines which, exactly in position, and partially in appearance, represent the actual features of the country. The topographical surveyor prepares a sheet of paper, fixed upon a board or sort of portable table, by laying down upon it all the points of the trigonometrical survey which fall upon the space which is to be represented on the paper. By means of the plotted points, and with the help of a few simple instruments, he locates on the paper all the minor details of the natural surface of the country; traces out and marks the exact positions of the roads and streams, the houses, bridges, churches, boundaries of forests, swamps and marshes, and other prominent features of the surface. His paper then becomes a map; its tracery of lines and its marks or signs presenting a picture which would bear a close resemblance to the face of the country, as it would be seen by a person far above and looking down upon it. The tracery of roads, streams and boundaries, and the positions of landmarks, although sketched in, have, nevertheless, been determined by exact measurements and by methods peculiar to topographic surveying; so that the picture or map is not a mere eye-sketch, but a drawing faithful to nature in all its parts, proportions and distances.

Contiguous portions of the country are mapped in the same manner, the sheets slightly overlapping, so that there can be no "forcing" in the fitting of the sheets to each other.

The details of topography are determined with the same relative degrees of accuracy that are found in the trigonometrical survey; that is, any distance can be taken from the map by a scale with as much accuracy as the scale can be read.

For a topographical map constructed on a scale of one inch to a mile a carpenter's rule would show by the number of inches and fractions of an inch between two points on the map the number of miles and fractions of a mile of horizontal distance on the ground;

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and the finer the divisions of the scale, the nearer could such distances be determined by the map.

There is one very important feature of the surface mapped which has not thus far, however, been provided for, as far as representation on the map is concerned; and to leave this feature out would leave the topographical map incomplete and deprive it of much of its value. This feature comprises the elevations and depressions of the surface, the undulations of the country, its hills, mountains and valleys. Thus far in our construction of a map there is nothing to show whether a road passes over a mountain or lies on a plain. There is nothing to show the particular region or the amount of surface upon which the rainfall is tributary to any particular stream; nothing to show whether a village or lake lies at the sea level or a thousand feet above it.

This vital and important information is introduced into the topographical map by means of a series of irregularly curved lines on the map called contours, or contour lines. For the purpose of explaining precisely what a contour line on the map represents, a simple illustration will be sufficient. Suppose one of the controlling points to be situated on the top of a high mountain or hill, and that the altitude at that point above the sea level has been accurately determined by levelling instruments. All that could be put on the map would be a *number*, stating the altitude of the point above the sea. The shape of the hill or mountain and its connection with adjacent hills to form a "range;" and the locations and shapes of the valleys between ranges of hills would still be unrepresented. Let us suppose, however, that the surveyor descends twenty feet in vertical distance below the top of the hill and runs a line around the hill, remaining all the time at the same level distance below the top He would trace out on the side of the hill what is called a contour; this contour would give the true shape of the hill twenty feet below the top all around, and such a contour he can project downwards and plot on his map. He then takes a second level, twenty feet lower, and determines the contour at that elevation, and plots this also, and so on. The first two or three contours may be closed curves, as though slices were cut off the top at the given elevations, and these slices did not extend to adjacent hills. But as the contours are made further down they begin to run into other hills, and will represent the level lines at successive intervals of twenty feet along the sides of a range of hills or mountains. When

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contour lines for a district or State are thus all plotted on the map, and referred to the sea level, the dividing ridges and the valleys appear on the drawing. With the topographical map before him the engineer can now trace out the boundary lines of the water-shed of a stream better than he could from a plaster cast representing the elevations and depressions of the country; he will know the grades in all roads, and can make proper plans for their improvement. He is able to see at once what low-lying districts can be drained, either for sanitary purposes or for the reclamation of land. In fact, all engineering operations which depend upon a knowledge of the undulations of the country can be, to a large extent, planned by the use of the map without the necessity for expensive and repeated special surveys. Even in farm drainage such maps are valuable as indicating the slopes of the hills and the shortest lines of descent.

For the improvement of roads alone, if there were no other uses for complete topographical maps, they would be worth all they cost. In fact, it is difficult to see how any systematic and economical plan of road improvements can be advantageously made without a knowledge of existing grades and the physical nature of the districts through which the several roads pass.

It need hardly be pointed out that the exact topographical maps are often of great value to the Legislature, especially where the boundaries of State lands and jurisdiction lines are concerned; nor is it necessary to refer to the value of such maps in all matters of internal improvement, such as the water-supply of towns, the development of mining and quarry interests, and the location and construction of new lines of traffic.

In these respects the rural districts are especially benefited by accurate maps in the increase of transient and fixed population and by the growth of industries and manufactures.

The plan of the United States Geological Survey is to begin work in different parts of the State where it shall appear in consultation with the Commissioners of the State Survey that maps are most urgently needed, and to construct maps on a scale of one inch to a mile, one hundred and eight (108) maps covering the whole State.

These maps will not only fit each other along their borders, but will also harmonize with the maps of adjacent States made upon the same plan.

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It has been shown by the surveys in contiguous States that these surveys including the engraving of the maps on copper, can be accomplished for ten dollars a square mile, or a trifle over one and a half cents per acre, the State paying half.

As compared with foreign surveys, this price is remarkably low.

An appropriation by the State of $40,000 for the first year will secure the survey of one-eighth the area of the State, or over 6000 square miles, and the same amount for succeeding years will complete the survey in seven years.*

The following named countries of Europe have complete topographical maps made in the manner above described and generally upon a scale approximating one inch to the mile: England, Ireland and Scotland, France, Belgium, Netherlands, Hanover, West Prussia, Hesse, Wurtemburg, Baden, Switzerland, Bavaria, Tyrol, Sardinia, Parma and the States of the Church, Illyria, Austria, Bohemia, Saxony, East Prussia, Silesia, Gallicia, Upper Prussia.

These maps were long since completed and are looked upon as having repaid their cost many times over, through the public and private benefits derived from their uses.

The following copy of the agreement made between the Commissioners for the Connecticut Survey and the Director of the United States Geological Survey may be of interest, as showing more precisely the nature of the co-operation between the State authorities and the United States Government:

*"Agreement between the Commissioner of the State of Connecticut and the Director of the United States Geological Survey for the Construction of a Topographical Map of Connecticut.*

"1. *The preparation of the Map shall be placed under the supervision of the Director of the United States Geological Survey, who shall determine the methods of survey and map construction.*

"2. *The work shall be based upon the triangulation of the United States Coast and Geodetic Survey, and wherever this is deficient it shall be supplemented by the United States Geological Survey.*

"3. *The survey shall be executed in a manner sufficiently elaborate to prepare a map upon a scale of* 1:62,500, *exhibiting hydrography, hypsography and public culture, and including all town and*

* The area of the State of New York is estimated to be 50,000 square miles.

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*county boundary lines in this State established at the time of its completion, and the preliminary field maps shall be on such a scale as the Director of the United States Geological Survey may select to secure accuracy in the construction of the final map* *

"4. *The hypsography shall be shown by contour lines with vertical intervals of twenty feet.*

"5. *The heights of important points, including dams, shall be determined and furnished to the Commissioners of Connecticut.*

"6. *The outlines of wooded areas shall be represented upon proofs of engraved maps to be furnished the Commissioners of Connecticut.*

"7. *For convenience the Geological Survey shall, during the progress of the field work, pay the salaries of the persons employed therein, while the travelling, subsistence and field expenses shall be paid for the same time by the State. For the office work on the maps the salaries shall be divided between the two agreeing parties in such a way as to equalize expenses, provided that the total cost to the State of Connecticut, of the field and office work, including the electro copper plates mentioned in Section 10 below, shall not be more than $25,000, less the necessary expenses of the State Commission.*

"8. *During the progress of the work free access to the field sheets and records of the topographers and draughtsmen shall be afforded the Commisioners for examination and criticism; and should the said Commissioners of the State of Connecticut deem that the work is not being executed in a satisfactory manner, then the said Commissioners may, on formal notice, terminate the agreement.*

"9. *The resulting map shall fully recognize the co-operation of the State of Connecticut.*

"10. *When the work is completed the Commissioners of Connecticut shall be furnished by the United States Geological Survey with photographic copies of manuscript sheets; and when the engraving is completed, said Commissioners shall be furnished by the said Survey with electro copper plates of the sheets of the map, without cost to the State, in excess of the $25,000 appropriated by the State, less the necessary expenses for the State Commissioners.*"

The Board of Commissioners of the New York Survey being still in office, it would doubtless be sufficient for the Legislature to authorize that Board to make an agreement with the Director of

* $\frac{1}{63360}$ is practically one inch to one mile.

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the Geological Survey, similar to the above; the cost of the survey of the State of New York being limited to $40,000 for the first year of the work.

The trigonometrical work already done under the State Board covers, as has been stated, about two-thirds of the whole State; the character of the work has been highly praised by Government authorities, and its cost was in no degree excessive.

But the expenditures will be practically lost unless the final operations, the topographic survey, be executed.

The cost of the survey of Massachusetts was $12.97 per square mile; that of Rhode Island, $8.97, and that of Connecticut, $9.79. The estimated cost for New York is $10.00 per square mile—the State paying half, or $5 per square mile—an exceedingly small investment, considering the economic value of the survey.

The map of Connecticut includes the locations of roads and streams, the boundaries of forests, the locations of farm houses, the contour lines over the whole State, and the boundaries of counties and towns.

The cost to the purchaser of a single sheet of the maps will be from ten to fifteen cents; and thus every farmer may have, at trifling cost, an exact map of many square miles of territory adjacent to his possessions, while as travelling maps the popular demands, judging from experiences abroad, are by no means likely to be insignificant or unimportant. The summer tourist or traveller may select his own routes and determine in advance the distances to be travelled, and the character of the roads as far as grades are concerned. Public interest in the interior attractions and resources of the country will thus be promoted by the increased facilities for journeying by the common roads.

It would seem to be a wise and economic policy for the State of New York to take immediate advantage of the opportunity of co-operation offered by the Government, especially in view of the fact that appropriations that may hereafter be made by Congress for the surveys of the States may be divided among several States, and the survey of New York thus very much delayed. The United States Government cannot, of course, take the initiative in the matter.

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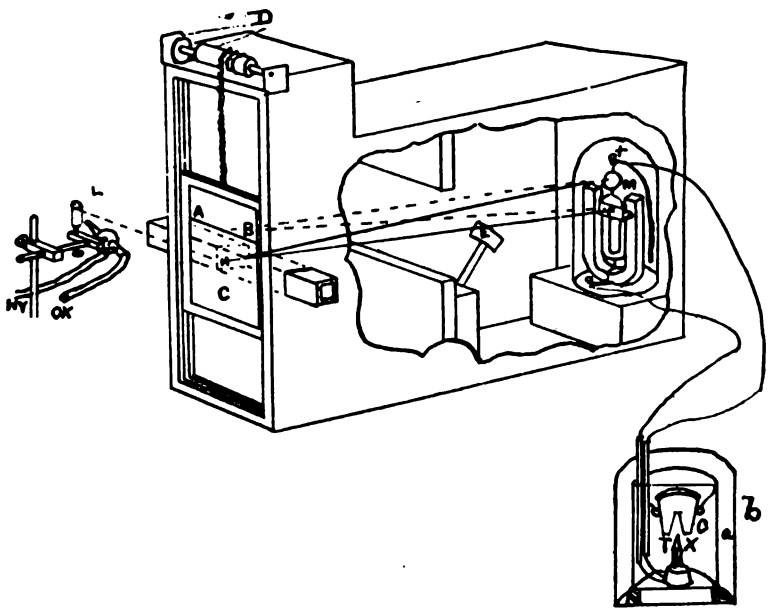
# PYROMETER OF M. LE CHATELIER (Supplementary Note.)*

By JOSEPH STRUTHERS.

This pyrometer is based on the fact that when two dissimilar metals are placed together in circuit and heated a current of electricity is produced, the strength of which is dependent on the temperature to which the metals are raised. There are essentially three parts to the pyrometer: the couple or thermo-junction, which produces the current of electricity; the galvanometer, which measures it, and the conductor connecting them.

The couple is composed of two wires, twisted or soldered together, one of platinum, the other of platinum with ten per cent.




rhodium. The galvanometer used is that of Déprez and D'Arsonval, slightly modified. The conductor is of common copper wire about 1 mm. diameter. The calibration is done by taking

* A complete description of this pyrometer was given in the School of Mines Quarterly, vol. xii., No 2..

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certain known temperatures and making a chart representing the value of the divisions shown on the scale of the pyrometer in thermometric degrees; a curve is then plotted and any intermediate temperature can be ascertained by reference to the chart.

An automatic method of observation has been devised for registering the results, and the following description is taken from a paper read by Prof. Roberts-Austen before the Iron and Steel Institute, May 7, 1891.

The illustration represents the apparatus for automatic observation, and consists of the galvanometer enclosed in a camera: a fixed mirror F being placed below the movable mirror M of the galvanometer, so that the light from the lime cylinder L reflected in the mirror H passes to both mirrors F and M, and is reflected in the direction of a fine horizontal slit A B, behind which a sensitized photographic plate C is drawn vertically past the slit by means of a gearing D driven by clockwork.

The ray from the fixed mirror is interrupted periodically by the vane E and a beaded datum line is given, which enables any irregularity in the advance of the plate to be detected.

The amount of divergence from its datum line of the spot of light reflected by the movable mirror at any given moment bears a relation (which can be found out by calibration) to the temperature to which the thermo-junction X is heated, and variations of temperature are recorded by a curve which is the resultant of the upward movement of the plate and the horizontal movement of the spot of light.

The complete arrangement is shown in the figure. The thermo-junction X is inserted in a tubulure of a specially constructed crucible of plumbago, which contains about 5 oz. of pure molten gold and is allowed to cool down slowly inside of a silver vessel 105 mm. in diameter, and polished internally. If the thermo-junction was immersed or brought into contact with the mass of metal which was being heated to melting, they would get a sinuous line traced on the advancing plate by the passage of the spot of light from the movable mirror in its efforts to get back to its zero. This photographic method of recording gives a very delicate means of ascertaining any molecular changes that might take place in iron or other metals when cooling, and has special application where continuous temperatures are desired.

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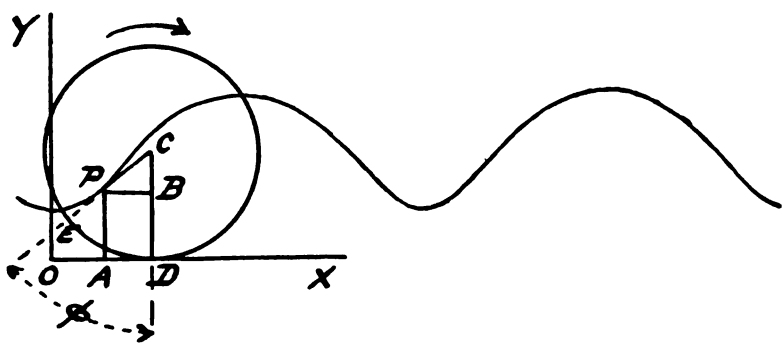
# THE PATH OF A LOCOMOTIVE CRANK-PIN.

By GEORGE F. D. TRASK.

THE following is a brief discussion of the path described by any point rigidly connected to a wheel which rolls in one plane on a straight track, such as the centre of a locomotive crank-pin.

To find the equation of the curve, assume the notation of the figure, in which the wheel rolls on the axis of $x$, and the axis of $y$ passes through the crank on its lower half centre. P is the centre of the crank-pin, whose path we wish to find.




Let $l = CP =$ the length of the crank, and $r =$ the radius of the wheel. Suppose the wheel to have rolled to the right any distance $OD$ from the origin, and call the corresponding angle from the vertical passed through by the crank, $\phi$.

From the figure we have

$$x = OA = OD \mp AD,$$

but

$$OD = DE = r\phi,$$

and

$$AD = PB = \sqrt{l^2 - (r-y)^2},$$

hence

$$x = r\phi \mp \sqrt{l^2 - (r-y)^2} \quad . \quad . \quad . \quad (1)$$

From the figure again,

$$y = AP = DB = r - l\cos.\phi,$$

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or

$$cos.\,\phi = \frac{r-y}{l}$$

hence

$$\phi = cos.^{-1}\frac{r-y}{l}$$

Substituting this value of $\phi$ in Eq. (1), we have

$$x = r\,cos.^{-1}\frac{r-y}{l} \mp \sqrt{l^2-(r-y)^2} \qquad (2)$$

which is the equation of the curve described by P.

If in Eq. (2) we make $y = r - l$, we have $x = o$, $x = 2\pi r$, $x = 4\pi r$, etc.

If we make $y = r + l$,

$$x = \pi r,\ x = 3\pi r,\ \text{etc.}$$

If we make $y = r$,

$$x = \frac{\pi r}{2} - l,\ x = \frac{3\pi r}{2} + l,\ \text{etc.}$$

It can be shown by the calculus that the length of the curve increases with $l$.

It is evident that Eq. (2) represents in general a curve whose limiting cases are a straight line, a circle, and a cycloid. To show this analytically:

1. If in Eq. (2) we make $l = o$, the only real values of $x$ must correspond to $y = r$, and $y = r$ is a straight line.

2. If in Eq. (2) we make $r = o$, it becomes $x^2 + y^2 = l^2$, which is a circle.

3. If in Eq. (2) we make $l = r$, it becomes

$$x = r\,\text{versin}^{-1}\frac{y}{r} \mp \sqrt{2ry - y^2}$$

which is a cycloid.

If $l > r$, the curve becomes a series of loops.

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# ANALYSIS OF CHROMITE.

By E. WALLER and H. T. VULTÉ.

CHROMITE, the mineral source of chromium compounds used in the arts is essentially a chromate of iron and is represented by the formula, $FeO,Cr_2O_3$. The theoretical composition calculated from this basis, is

FeO, 32 per cent.
$Cr_2O_3$, 68 per cent.

The mineral is frequently associated with magnesia, silica and manganese; the full list of possible constituents of the ore is that usually given for iron ores.

The chromium is usually the most important constituent and chromic oxide alone is determined. The refractory character of chromite is well known and many efforts have been made to perfect a scheme of separation and estimation of the chromium, which would be at the same time simple and accurate.

The following methods may be recalled. They are divided in two distinct classes: First, those making use of liquid reagents. Second, those in which fusion is used. Of the first class we mention the following:

1. Boiling with nitric acid and potassium chlorate, Storer, *Proc. Amer. Acad.*, iv., 432; Pierson, *Am. Jour. Sci.* [2], 48, 190; Pawolleck, *Ber.*, xvi., 3008. Baubigny, *Bull. Soc. Chem.*, 1884 [2], xli., 291, finds this method very satisfactory. Many others however, have found it tedious or unsatisfactory or both, and such has been our experience.

2. Heating with bromine water in a sealed tube at 130° — 170° C., for several days, E. F. Smith, *Am. Jour. Science* [3], xv., 198. It is obvious that the length of this operation constitutes a very serious objection.

3. Heating for several hours at 200° C. with sulphuric acid (1 part $H_2O$ and 2 parts $H_2SO_4$ by weight) in a sealed tube, Mitscherlich, *Jour. Prakt. Chem.*, 81, 108 and 83, 455.

Sulphuric acid of specific gravity 1.34 was found by Philips, *Fres. Zeits.*, xii., 189, to give the best results. The time required for this operation is about ten hours. Serious objections may be urged against these methods both from length of time required

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and danger of explosion. Of the second class, or fusion methods we find:

1. Acid potassium fluoride, Gibbs, *Fres. Zts.*, iii., 328, also Dubois, *Fres. Zts.*, iii., 401; these chemists use four to five times the weight of ore in flux and fuse from ten to fifteen minutes.

2. Alkaline or alkaline earth fluoride in conjunction with alkaline bi-sulphate, Sill, *Jour. Lond. Chem. Soc.*, xxxv., 292; Clarke, *Am. Jour. Science*, 1868, 173; Hagen, *Untersuchungen*, i., 163. The use of fluorides requires special management to avoid the subsequent destruction of glassware and involves more manipulation and skill than is required by some of the other methods.

3. Potassium bi-sulphate alone, Reinhardt, *Chem. Ztg.*, xiii., 430. This method is not efficient uunless extraordinary precautions are taken in pulverizing the ore.

4. Potassium bi-sulphate followed by potassium chlorate and sodium carbonate, O'Neill, *Chem. News*, 1862, 199.

5. Potassium bi-sulphate followed by potassium nitrate and sodium carbonate, Oudesluys, *Chem. News*, 1862, 254; Hunt, *Amer. Jour. Sci.* [2], v., 418, adds a little alkaline nitrate towards the end of the operation.

6. Caustic alkali with or without the addition of lime, Pellet, *Berg. u Huttenman Ztg.*, xl., 224; Christomanos, *Ber.*, x., 10, substitutes magnesia for lime. Morse and Day, *Amer. Chem. Jour.*, iii., 163, advocate the use of an iron crucible.

7. Caustic or carbonated alkali in conjunction with an oxidizing agent. Potassium chlorate is recommended by Schwartz, *Annalen*, lxix., 212, and Blodgett-Britton, *Chem. News*, xxi., 266. Alkaline nitrate is recommended by Calvert, *Jour. Lond. Chem. Soc.*, v., 194; Peligot, *Comptes Rendus*, 67, 871; Clouet, *Comptes Rendus*, 67, 762. Barium dioxide is recommended by Donath, *Ding. Polyt. Jour.*, cclxiii., 245; Kinnicut and Paterson, *Jour. Anal. Chem.*, iii., 132.

8. Alkaline carbonates with borax, Dittmar, *Ding. Polyt. Jour.*, ccxxi., 450 and Iron, January, 1876, p. 131. The flux is composed of three parts of a mixture of potassium and sodium carbonates with two parts of borax glass.

9. Alkaline carbonate with some borax and alkaline nitrate, P. Hart, *Jour. Prakt. Chem.*, lxvii., 320.

The wet methods and those by fusion with fluoride have already been briefly discussed. Fusing alkaline bi-sulphate in our experi-

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ence does not readily decompose chromite unless it is in a state of subdivision not easily obtained. Elutriation is not a desirable method of obtaining the necessary state of comminution, since the chromite possesses such a high specific gravity (about 4.5) that by elutriation a partial separation of that mineral from its associated minerals in any given sample will result, tending to produce incorrect results.

Fusion with caustic alkalies requires the use of a silver or iron crucible. Such crucibles need to be thick as compared with those of platinum and consequently require the application of a higher heat to keep the melt at the proper temperature during fusion. Moreover, if oxidizing agents are used in these crucibles they deteriorate rapidly.

Of course where alkaline fluxes only are used the decomposition is effected by the oxidation of the chromium to chromic acid and its union with the alkali. The presence of an excess of base with a plentiful access of the oxygen of the air, favors such a change and indeed is the method utilized in the manufacture of chromium salts from the ore.

The following process based on such a fusion with subsequent special treatment has been found to give satisfaction and is thought to be more simple, accurate and rapid than any method heretofore proposed. The plan of procedure is:

*a.* Fuse 0.5 to 1 gm. with five or six times its weight of Dittmar's flux in a platinum dish.

*b.* Dissolve in water, filter and evaporate, adding a little ammonium nitrate from time to time, until the last addition fails to give any odor of ammonia on heating the solution. Continue the evaporation to dryness, moisten with a few drops of nitric acid and heat until dry.

*c.* Take up with water containing a few drops of nitric acid, add hydrochloric acid and sulphurous acid, or a little ammonium sulphite, boiling out the excess of $SO_2$.

*d.* Neutralize with ammonia and boil, adding a little ammonium sulphide. Re-dissolve in hydrochloric acid, and reprecipitate as before to purify the precipitate. Ignite and weigh $Cr_2O_3$.

*Comments—a.* The flux is made by fusing together two parts of borax glass with three parts of (dry) sodium and potassium carbonates, mixed approximately in proportion of their molecular weights (106 to 138). After fusing the mixture is poured out

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upon a cold surface (a dry platinum dish floated on the surface of cold water) and then coarsely powdered for use. As it is somewhat hygroscopic, it should be kept in a tightly corked bottle. The borax makes the flux somewhat pasty, so that it holds the mineral partly in suspension, and thus favors the decomposition. A convenient form of dish for the fusion is one about 2 inches in diameter, and half an inch deep, with rounded bottom and provided with a small ear for grasping with the tongs. If a shallow dish of the kind is not available, the convexity of the cover of a large fusion crucible makes a very good substitute. The flux has practically no effect upon the platinum. Over three hours of fusion caused in one case a loss of 3.5 mgms. and ordinarily little or nothing.

A good way of managing the fusion is first to melt in the dish the requisite quantity of flux, and then allow it to cool; then weigh out the finely pulverized ore, and by means of a feather brush it on to the surface of the melt, spreading it as evenly as possible.

Then fuse with a good Bunsen burner, stirring occasionally with a platinum wire, until the decomposition is apparently complete. This is likely to require not over forty minutes, if the ore has been well pulverized, and the stirring has been sufficiently frequent. If either point has been neglected it may require longer. Remove the heat temporarily, and as the mass cools, stir with the platinum wire in such a way as to take a portion of the material from the bottom of the melt. As soon as this hardens sufficiently, withdraw and examine it for black grains of undecomposed ore. If any are seen, replace the test bead in the dish, cover, and apply the heat. The material soon melts off from the wire, when the cover may be removed, unless the heat is insufficient to keep the mass fluid without its use. When decomposition is apparently complete, remove the heat and allow the mass to cool.

*b.* The portion soluble in water, besides the excess of the constituents of the flux, should contain all of the chromium as alkaline chromate, together with some alkaline manganate, aluminate and silicate. That insoluble in water should dissolve completely in hot dilute hydrochloric acid. If some black grains of undecomposed ore remain, they must be filtered off and fused with a little more of the flux as in the first instance.

The evaporation of the water solution, with addition of ammo-

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nium nitrate (*Genth. Chem. News*, vi., 32) cause the manganese to separate as insoluble $MnO_2$, the alumina being at the same time precipitated as hydrate, which by the prolonged heating assumes a form practically insoluble in nitric acid, especially when hot. The last addition of nitric acid and heating will render all of the silica insoluble, so that eventually nothing soluble remains except alkaline chromate and nitrate.

*c.* The object of this step is simply to reduce the chromium to the form of base. The presence of hydrochloric acid is of advantage in the next step, as it affords ammonium chloride which favors the separation of chromium hydrate.

*d.* It may be found that at first no precipitate appears on neutralizing with ammonia. On boiling, however, to remove the slight excess of ammonia, chromium hydrate separates. The addition of a little ammonium sulphide favors the separation. The precipitate produced in presence of the fixed alkalies is, however, never sufficiently pure to be at once ignited and weighed. After washing it requires at least one re-solution in hydrochloric acid and re-precipitation in the same manner as before. A third re-precipitation may be advisable.

If alkaline salts remain with the precipitate, the error involved is not only due to the additional weight of those contaminants, but they may induce a further increase in weight due to the partial formation of alkaline chromate.

List of analyses made by the preceding method:

| | | $Cr_2O_3$ found, per cent. | $Cr_2O_3$ calc. per cent. |
|---|---|---|---|
| 1. | Chromite and Iron Ore, | 4.18 | 4.38 |
| 2. | " " | 2.92 | 2.80 |
| 3. | " " | 3.87 | 3.96 |
| 4. | " " | 2.75 | 2.64 |
| 5. | " " | 2.57 | 2.72 |
| 6. | " " | 2.98 | 2.88 |
| 7. | " " | 4.44 | 4.32 |
| 8. | " " | 4.027 | 4.07 |
| 9. | " " | 8 44 | 8.64 |
| 10. | " " | 3.52 | 3.51 |
| 11. | " " | 2 77 | 2.907 |
| 12. | " " | 10.57 | 10.60 |

These samples were made from a chromite mixed with iron and manganese ores. The chromite was found to contain 57.00 and 57.025 per cent. of chromic oxide as a result of determination by different analysts.



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# THE FOSSIL FORESTS OF THE YELLOWSTONE.

By WALTER HARVEY WEED.

THE name of fossil forest has been so often used to call attention to small collections of prostrate tree trunks of siticified wood that one scarce expects more of the locality bearing this designation in the Yellowstone Park. Yet the name of fossil forest is a most appropriate one for this collection of upright tree trunks, which, seen at a little distance, closely resemble the skeleton trunks of their living relatives near by.

The particular locality to which attention is called, and to which the name of The Fossil Forest is applied, is in the eastern part of that great national pleasure ground, the Yellowstone Park. Although easily reached by a fairly good wagon road, which forms the mail route to the little mining camp of Cooke, Montana, the locality is seldom visited, save by those vandals who have carted away its treasures by the wagon load to be shipped to the dealer in "specimens." The region is a picturesque one; the broad, wide valley of Lamar river, with its great meadows and groves of tall cottonwoods is enclosed by grassy foothills, the slopes dotted with patches of the quaking aspen. The steeper slopes that rise upward to the mural cliffs that face the valley are dark with pines and the picturesque Douglas spruce. To the eastward Soda Butte Valley penetrates the heart of the rugged Sierra, whose high peaks rise in castellated forms. The visitor, disappointed perhaps in the mountain scenery of the park, after travelling the usual route over the dusty roads of the park plateau, will here find mountain views that are sure to fulfil his expectations, while the neighborhood is not lacking in curiosities that in another land would attract visitors from far and wide.

Soda Butte, a cone of hot spring limestone (travertine) that gives its name to the creek flowing by it, is only worthy of notice as a ruin, but the cold springs near by are highly charged with mineral salts and gases, and whether the visitor be bettered in health by a glass of it or not the spring is sure to be remembered by all who have tasted its mal-odorous waters. The only accommodations in this part of the park are to be obtained here, and

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though far from luxurious the cabin that serves as mail station is not lacking in the usual frontier comforts. A couple of miles from here is an area of many acres of whitened rocks, where sulphurous gases, still ascending, have formed banks of sulphur, the surface covered by a dark gray crust whose ropy forms resemble scoria and wholly lack the bright primrose color of sulphur, though composed entirely of it.

A few miles beyond is Death Gulch, whose deadly vapors have killed a number of bears, their skeletons and fur lying strewn about its bottom, while other and smaller game occasionally venture in the walls, and, succumbing to its vapors, serve as bait for the next victim. The mortuary interest of this peculiar valley of death overshadows the attention aroused by the beautiful deposits of calcite, an old hot spring deposit and the iris pools of acid chalybeate water near by.

The geological structure of this region is comparatively simple, though the details of its history required patient investigation. Lava flows and great quantities of fragmental volcanic rocks, forming beds of breccia, aggregating thousands of feet in thickness, rest upon the eroded surface of nearly horizontal limestones, carrying Paleozoic fossils. These breccias, which formerly covered the entire eastern part of the park, now form the high and rugged peaks of the Absarokas, and are cut into deep cañons, high plateaus and towering mountain summits. Since their deposition they have been covered with subsequent lava flows, while the last act of the dying volcanic forces filled the valley bottom with basalt. The volcanic breccias, which occur in beds of varying thickness, are composed of fragments of all sizes; they generally show a rude assortment, and are separated by intercalated bands of volcanic tuffs. The rocks are all andesitic and basaltic, but vary considerably in their character. It is in these beds of breccia that the fossil trees occur, their roots imbedded in the tuffs that once formed their soil, and which now contain an abundant and extremely beautiful collection of leaf remains.

The particular locality designated as the fossil forest, for fossil trees occur at many other places as well, is the bluff wall on the west side of the Lamar Valley opposite the mouth of the Soda Butte Creek, a bare exposure of the breccia rocks and tuffs some 1600 feet in height, where the weathering of the rocks has left the tree trunks standing out in bold relief. When first discovered in

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1878 the beds of breccia contained great quantities of agate, amethyst and chalcedony, but these minerals are now rarely seen, having been carried away by visitors in search of "specimens." In recent years even the fossil trees themselves have been taken away when small enough to be readily transported. The discoverer of this interesting feature of wonderland was Mr. W. H. Holmes, who made a brief study of the geology of the region for the Hayden Survey in 1878, and published a graphic account in the twelfth annual report of the survey. The accompanying plate, showing the breccia mountains and the valley of Soda Butte creek, east of the Fossil Forests, is from a drawing by this versatile artist and geologist.

These volcanic agglomerates, which, as has been mentioned, characterize this region, attain a thickness of several thousand feet in this vicinity, and are here for the most part horizontal. At certain localities, of which the fossil forest is the best known, these bedded volcanic rocks are full of upright fossil tree trunks.

Turning aside from the wagon road before reaching Soda Butte creek and crossing the grassy footslopes, the detritus from the little ravine that drains the cliffs attracts attention by the large amount of fossil wood, agate and chalcedony which it holds. Reaching the steeper slopes at the base of the cliffs the rocks are concealed beneath the abundance of flowers and grass, but sections exposed in the ravine show fine-grained beds of volcanic ash and agglomerates, in which leaf remains were found, but no tree trunks. Above these grassy slopes the steep surface of the bare buttress ridges that lead to the cliffs above are strewn with broken tree trunks and wood. Some 500 feet above the valley the fossil trees are numerous. Trunks and fragments of trees were found in great numbers and in all conceivable positions. In most cases the woody structure is well preserved, and the trunks resisting the weathering that causes the enclosing rocks to crumble away, stand out in pillars of varying heights. Cross fractures produce a tendency to break in sections on whose surfaces weathering has brought out the annual rings. Often the trees have been replaced by casts of chalcedony or agate, and frequently the trunks are hollow and lined with quartz and amethyst crystals. The large size and fine state of preservation is especially noteworthy. Upright trunks rise from a ledge as broken columns of varying heights. As these trunks break into sections by cross-fractures it is not often that they attain

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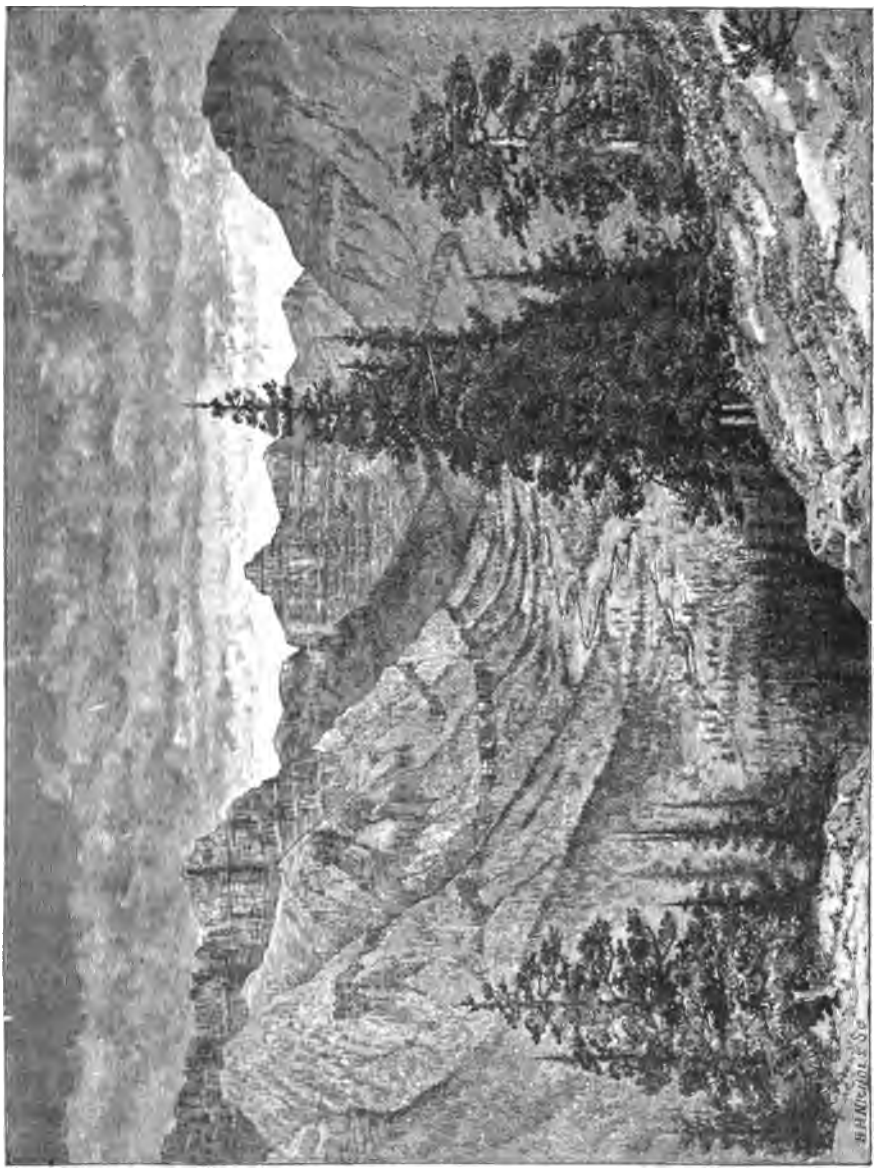
any great height, the rock wearing away but little more rapidly than the trees themselves.



In many instances the roots are exposed and may be seen penetrating the solid rock that once formed the surface soil. The

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largest upright trunk is an old stump 10 feet across and some 12 feet high. The woody structure is not so well preserved as is the case with the smaller trees, but microscopic sections show it to be coniferous. The bark is without structure, four inches thick and retains the outer surface quite perfectly. Prostrate tree trunks are of frequent occurrence, sometimes as much as 50 feet long and 5 to 6 feet in diameter. The higher parts of the cliff show an abundance of trunks, often 20 to 30 feet high, their roots imbedded in the fine-grained rocks, their branchless and battered trunks enclosed in the coarse breccias or agglomerates that form so large a part of the rock series. A careful study of the rocks has shown that they are all the products of explosive volcanic action or of mud flows of volcanic dust or ashes. Fine-grained shaly beds of light brown, grayish or bright green tints alternate with coarse agglomerates of non-assorted angular fragments of basaltic lavas.

The history of these buried forests is that of the volcanic agglomerates of the region, and has only been made clear by a careful study of the region for many miles to the eastward. Some forty-five miles in that direction the bedded volcanic rocks lose their persistent horizontality; are cut by massive dikes that weather out in great walls miles in extent. A high but flat-topped mountain in the rugged, almost impassable country about the head of Crandall creek has proved to be the key that unlocks the secrets of the past ages. It is the heart or core of an old volcano, and the mountain, with the neighboring country, as far away as the Fossil Forests, is indeed a dissected volcano, once rivalling Etna in size. The detailed evidence, which has been carefully worked out by the Yellowstone Division of the Geological Survey, shows that the region was once a country of hills and valleys, in which granites and Paleozoic limestones were exposed as the result of long-continued erosion. In the eastern part of this region volcanic forces found an outlet in a break through the limestones, and explosive eruptions covered the country with a heavy mantling of ashes and lapilli, and about the vent built up a cone of coarser material, the blocks of ejected lava and bombs cast out of the volcano's throat.

Lava flows succeeded, and were in turn covered beneath more volcanic *débris*, and thus a great cone was built up that the observed facts show must have been some 10,000 feet higher than the summit of the present mountains,—a great volcano, yet not larger than those of the present day.

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Upon the lower and gentle slopes of this volcano vegetation flourished and forests grew up, until explosive eruptions of unusual violence buried them beneath an accumulation of ejected material. In eruptions of the active volcanoes of to-day that have been studied, similar cases are not uncommon. The eruption of Krakatoa in 1883, and of Tarawera, New Zealand, in 1886, were of this nature. The trees, stripped bare of leaves and limbs by the violent winds that accompany these eruptions, were buried beneath the mud showers and streams, and by the later fall of stones and great blocks of lava. In such a way the forests that first grew upon the flanks of the great Crandall creek volcano were buried beneath the ashes, muds, and *débris* of the eruption.

In a period of quiet succeeding, a new forest flourished and grew up, only to be in turn buried beneath the showers of rocks; and this was repeated until there were, as the cliffs now show, no less than ten or more buried forests, one upon another.

Since the dying out of the volcano, wind and rain and frost have carried away the cone and laid bare the plug of lava that filled the heart of the old volcano, and its flanks now form the mountain ridges, peaks, and plateaux of the present country. It is only about the flanks of the old volcano that fossil trees are found, as it was only there that vegetation flourished in the intervals between the greater explosions of the vent. To-day the streams have cut deep cañons in the volcanic rocks, and again exposed the underlying limestones and granites to view.

The trees thus buried have been beautifully preserved. Prostrate trunks and upright trunks alike are as perfect in form as the day they were imbedded in the rocks. By what process has the soft and perishable woody tissue been converted into stone is a question often asked. If a piece of the petrified wood be ground down until it is almost transparent and examined under a microscope, it will be found to show every detail of the woody structure as perfectly as a slice from the wood of a modern tree, yet the material is wholly silica. It is evident the process of transformation has been a most thorough and, we are led to believe, a slow one. The actual silicification of pine wood about the present hot springs of the Park has led to a belief that it was by a similar agency that the petrifaction of these forests was accomplished. This is not, however, the case. The rocks about them do not show the alteration produced by hot waters, but rather the infiltration of sur-

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face waters, which, charged with silica derived from the readily soluble minerals, found an easy passage through the porous rocks. The rotting wood wetted by these waters produced a chemical precipitation of the silica, particle by particle, until the entire trunk was fossilized, and the centre often filled by the beautiful crystals of limpid quartz or amethyst now so often found. Not only were the trees thus silicified, but the seams and crevices of the rocks were filled with silica, and, later, by calcite from the percolating waters.

The geological importance of the Fossil Forests lies in the light the trees and leaf remains throw upon the nature of these ancient forests. The leaf impressions, so abundant in certain layers, show a wide variety of trees of types referred to the Miocene age, so that they afford evidence, which a study of other features of the geology of the region confirms, of the time at which this volcano was active. The leaf remains are often quite beautiful, the dark-brown color showing in most pleasing contrast to the bright-green tint of the rock itself. Delicate ferns flourished beneath great conifers, and tulip trees, walnuts, maples, and other congenitors of living species formed great forests.

A large collection of plant remains from this region has been made, and is in the hands of Prof. L. F. Ward, of the U. S. National Museum, for examination, so that an interesting account of the flora of this olden time may be expected soon.

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## CONTRIBUTIONS FROM THE MINERALOGICAL LABORATORY OF COLUMBIA COLLEGE.

By A. J. MOSES and L. McI. LUQUER.

### Alabandite from Tombstone, Arizona.

According to the description of Mr. Staunton, the Superintendent of the Tombstone Mining Company, a mineral, which we have determined to be the manganese sulphide alabandite, was found in April, 1891, "in the footwall of the Lucky Cuss fissure-vein in a pure white, strongly crystalline limestone. The mineral was found by following a body of oxide of manganese and lime spar ore which gradually merged into it, reaching a point where there was little else, and this afterwards gradually merging into the sulphides of iron, zinc and copper, with still a small amount

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of the manganese sulphide. This is the present condition of the working." "The deposit is about 100 feet above the water-level of the mine, and it is singular that it should have remained undecomposed while another adjacent deposit is thoroughly decomposed to a depth of fifty feet below the water level, the lowest point yet reached." The deposit is known to be cut off in one place by a granite dike.

Several rough crystals with a dull or velvety lustre were found, the best of which was a cube about 5/8 of an inch on a side. On this crystal the octahedral plane was represented by a concave surface coated with a thin layer of calcite, the intersection edges with the cube face being fairly perfect. A twinning was distinctly seen in this crystal, the line of intersection of the twinning plane with a cube face making an angle with a cube edge of 135°, and by hand measurements the diedral angle of which this line of intersection is the edge, was approximately 110°, theory requiring 109° 28′. Measurements made upon another rough crystal gave the same angle of about 110°.

The cleavage is very easy parallel to the cube, and much of the material is cleavable massive, and when broken does not yield broad cleavage faces, but a series of rather small planes meeting at definite angles, corresponding to the angles due to the octahedral twinning observed in the crystals.

Frequently a feather-like structure is observed due to the meeting along a twinning plane of the lines of cleaveage. At other times this structure is apparently produced by the meeting, along a common plane, of a number of imperfectly formed cubic crystals, the edges of these cubes making the same angle with each other that is required for twinning parallel to an octahedral face; and the faces of the imperfect cubes being represented by a series of step-like planes, which are sometimes 1/2 inch by 1/8 inch in size. In certain cases repeated twinning has produced rosettes.

The mineral is of a dark lead gray to iron black color. Tarnish brown or bronze-like, sometimes iridescent. Streak and powder are olive green. A very thin section of the mineral became translucent and by transmitted light showed a beautiful grass green color, though by reflected light it was still metallic. This section was found to be perfectly isotropic between crossed nicols.

The lustre was bright and metallic on fresh cleavage, the

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hardness was between 3 and 4, and the specific gravity on very pure cleavable material gave as two results, 4.031 and 4.040. Before the blowpipe the mineral became brown and fused rather easily with decided intumescence to a brown slag; in the open tube it became brown and evolved sulphurous fumes, with soda it yielded strong manganese and sulphur tests. In cold, dilute nitric acid the powder was instantly dissolved with rapid effervescence and strong odor of sulphuretted hydrogen; in cold dilute hydrochloric acid it dissolved less rapidly. The chemical analysis made, with great care, by Mr. G. J. Volckening, Jr., yielded:

$$\begin{aligned} S &= 36.907 \\ Mn &= 63.034 \\ \hline & 99.941 \end{aligned}$$

corresponding strictly to MnS.

In the cleavable calcite, which is the principal associate, are found small, glassy grains of quartz, sometimes of a rosy color, a few bright crystals of pyrite and a few grains of a yellowish garnet. Upon one or two specimens rhodochrosite was found, and the cleavage surface of one specimen was noticed to be coated with a mineral resembling proustite from which a silver button was obtained by cupellation. As Mr. Staunton speaks of the silver contents being $10 per ton it is probable that the silver was derived from small amounts of this mineral.

On one specimen, in very much decomposed calcite, minute bunches of bright, metallic, needle-like crystals were found. A coating of bluish botryoidal chalcedony was noticed on another specimen.

### Wavellite from Florida.

Mr. W. de L. Benedict recently presented to the mineral cabinet of the School of Mines a specimen of the ordinary white phosphate rock from the No. 9 mine of the Dunellen Phosphate Company, Marion Co., Florida. Upon the specimen were a number of small globular aggregates about 4 mm. in diameter, which, under magnification, were found to be composed of minute crystals (about 0.2–0.3 mm. in breadth) radiating from a common centre. Upon more careful examination these were found to be definitely orthorhombic, with the macrodiagonals approximately parallel, the prevailing form being a combination of a prism,

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macro-dome and brachy-pinacoid, and some very minute faces, apparently of a brachy-dome or a brachy-pyramid.

The structure and occurring planes suggested wavellite. To confirm this, qualitative tests were made, which proved the presence of $Al_2O_3$, $P_2O_5$, $H_2O$, and absence of CaO; the hardness was found to be a little over 3, the specific gravity 2.492. With the ordinary revolving stage and a half-inch objective, the following angles were obtained, which compare with wavellite as well as the method of measurement would permit:

| | Florida Phosphate. | Wavellite. |
|---|---|---|
| Prism, | 127° 15′ | 126° 25⅓′ |
| Dome, | 105° 27′ | 106° 46½′ |

The material is externally pinkish, but in small fragments is transparent and yellow, the apparent pink color being due to a little white dust coating the yellowish-brown material.

Analysis by Mr. G. J. Volckening, Jr. yielded:

$Al_2O_3 = 37.076$
$*P_2O_5 = 33.887$
$H_2O = 26.366$

97.329

## A RAPID METHOD OF DETERMINING THE COMPOSITION OF LUBRICATING OILS.†

By HAROLD GRIPPER, F.C.S.

The great majority of the oils now used for machine-lubricating are mixtures of hydrocarbon and saponifiable oils. The existing methods for the determination of these constituents are accurate and easily worked, but somewhat tedious, all consisting in saponification and subsequent separation by extraction of the hydrocarbons with ether. The usual process (described in Allen's *Commercial Organic Analysis*, vol. ii., p. 83) involves saponification, evaporation of the alcohol, dilution with water and cooling, separation in a separating funnel with ether, and finally evaporation of the ethereal layer and weighing of the residue. All this takes time, even if the separation in the separating funnel takes place rapidly, which is not always the case.

The following process I have found useful when a number of samples have to be examined at the same time, and when results

* $P_2O_5$ and $Al_2O_3$ were determined upon only 30 m.g. of material.

† *Chemical News*, vol. lxv., p. 27.

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approximately correct only are required, as is often the case in this laboratory. The results obtained are within 2 or 3 per cent. of the truth. The method is simply an extension of the well-known Kœttstorfer process. Two and a half grammes of the sample are saponified in the usual way with 25 c. c. of a solution of alcoholic potash about N/3 (with oils containing more than 50 per cent. of saponifiable oil the usual N/2 strength may be used). When saponification is complete the titration is made in the ordinary way with N/2 HCl, using phenolphthalein as indicator, and a blank experiment having been made to estimate the strength of the alcoholic potash used, the percentage of KHO used by the sample is calculated.

The saponifiable oils chiefly used in the making of mixtures for lubricating purposes are:

| | KHO absorption. Per cent. | Saponification equivalent. |
|---|---|---|
| Brown cotton-seed, | 22.27 | 252 |
| " rape, | 20.03 | 280 |
| Neatsfoot, | 18.70 | 300 |
| Lard, Tallow, | 19.30 | 290 |
| Castor, | 17.90 | 313 |

The potash absorptions therefore vary between 17.90 per cent. and 22.27 per cent. It is necessary to take the mean of these figures (20.08 per cent.) as the potash absorption of the unknown mixture of saponifiable matter in a lubricating oil. Then $100.0/20.08 = 4.98$ parts of the oil are saponifiable by 1 part of KHO. Therefore if the percentage of KHO absorbed by the sample be multiplied by 4.98, the amount of saponifiable matter present will be obtained. Or the calculation may be simplified by multiplying the number of c. c. of N/2 HCl (corresponding to KHO neutralized) by $(0.02805 \times 40 \times 4.98) = 5.587$. The proportion of saponifiable oils is thus obtained. The amount of hydrocarbon oil is ascertained by difference.

But it is necessary to know the specific gravity of the hydrocarbon oils. In order to estimate this, the liquid in the oil flask is, immediately after titration, raised again to the boiling-point, and poured through a filter paper which has been saturated with boiling water. The alcoholic solution of soap and KCl will run through in two or three minutes, the hydrocarbon oils remaining

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on the filter. They are washed once with boiling water, and the specific gravity may then be taken by Hager's method. It is not necessary to wash the oil more than once, since in making Hager's test the globule of oil dropped into the alcoholic liquid is immediately cleansed thereby from all impurities. The specific gravity of the hydrocarbon oils and of the original mixture being known, the specific gravity of the saponifiable oils may be calculated by difference.

By this method an analysis may be completed, including the calculation of results, within an hour of the commencement of the saponification, and in examining a series it is of great advantage, a dozen samples being easily completed in a day. The only source of error is in the fact that the nature of the saponifiable oil, and therefore its exact saponification equivalent, is unknown.

| | By Titration. | | By Separation and Weighing. | |
|---|---|---|---|---|
| | Per cent. | Sp. gr. | Per cent. | Sp. gr. |
| I. | 78.3 of hydrocarbon oil, | 0.891 | | |
| | 21.7 of saponifiable oil, | 0.950 | | |
| | 79.4 of hydrocarbon oil, | 0.891 | 79 3 of hydrocarbon oil, | 0 890 |
| | 20.6 of saponifiable oil, | 0.955 | 20.7 of saponifiable oil, | 0.957 |
| | 78 3 of hydrocarbon oil, | 0 891 | | |
| | 21.7 of saponifiable oil, | 0.950 | | |
| II. | 72.7 of hydrocarbon oil, | 0 900 | 74.4 of hydrocarbon oil, | 0.900 |
| | 27.3 of saponifiable oil, | 0 973 | 25.6 of saponifiable oil, | 0.9 9 |
| III. | 76.6 of hydrocarbon oil, | 0 882 | 76.7 of hydrocarbon oil, | 0.883 |
| | 23.4 of saponifiable oil, | 0.936 | 23.3 of saponifiable oil, | 0.953 |
| IV. | 65.4 of hydrocarbon oil, | 0.887 | 64.1 of hydrocarbon oil, | 0.886 |
| | 34.6 of soponifiable oil, | 0.966 | 35 9 of saponifiable oil, | 0.964 |
| V. | 79.9 of hydrocarbon oil, | 0 885 | | |
| | 20.1 of saponifiable oil, | 0 963 | | |
| | 79 6 of hydrocarbon oil, | 0.885 | 79.8 of hydrocarbon oil, | 0 886 |
| | 20.4 of saponifiable oil, | 0.962 | 20.2 of saponifiable oil, | 0.959 |
| | 79.9 of hydrocarbon oil, | 0.885 | | |
| | 20.1 of saponifiable oil, | 0.963 | | |
| VI. | 56.5 of hydrocarbon oil, | 0 906 | 58.1 of hydrocarbon oil, | 0.908 |
| | 43.5 of saponifiable oil, | 0.966 | 41.9 of saponifiable oil, | 0 965 |

The accompanying results were obtained by the process described, and by the usually accepted method of separation with ether and weighing the hydrocarbons. The results are in all cases in approximate and in some cases in close agreement.

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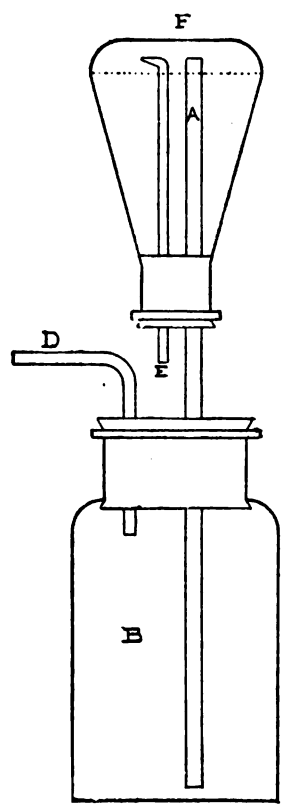
## A SIMPLE SUBSTITUTE FOR THE KIPP GAS GENERATOR.

By JAMES MASON KNOX.

The annexed cut illustrates a simple substitute for the Kipp Gas Generator.

It consists in a wide-mouthed bottle B, connected with a flask F by a piece of heavy glass tubing A, which extends from the bottom of B through the bottle and flask as shown in the cut.




This tube should fit tightly in B, but only so snugly in F as to prevent leakage. A delivery tube D, passes through the stopper of the larger vessel B, and may be provided with a stop-cock or

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pinch-cock if desired. Another tube E, is passed through the rubber stopper of F and either bent over or bent to one side and drawn to a jet as shown in the cut.

To operate, a layer of pumice stone is put into the bottom of B to prevent the solid material from lying in any residual acid. After this the solid material, as iron sulphide, is introduced upon the pumice stone. The flask F is filled with acid, the end of A remaining above the liquid.

When the gas is required the flask F is slipped up along the tube A, allowing the acid to run through this tube into the lower vessel, air entering through E as the acid escapes.

To stop the generation the flask is slipped down and the tube D closed until the gas has driven the acid back into the flask.

The advantages of this apparatus over the other substitutes for the Kipp Generator are, that in case of the usual leakage around the fittings of B and D when the apparatus is not in use, the acid will not run down into the lower vessel, as the end of the tube A is kept above the level of the liquid in F except when being used. And that the quantity of acid brought into use can be regulated by the extent to which the flask is slipped up. This prevents excess of effervescence and the consequent boiling over of the liquid through the delivery tube.

The apparatus is cheap and simple, and easily taken apart to be cleaned.

The stopper need not be removed from F in refilling, as the acid may be poured into B and from there driven up into F by the gas.

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## SOAP, ITS FABRICATION AND ANALYSIS.*

By H. T. VULTÉ, Ph.D.

In a broad sense the term soap includes the compounds of the higher fatty acids with alkali or other metallic bases. The former being soluble and the latter insoluble in water. It is to the first class, namely, the soda and potash compounds, that the term soap is particularly applied; the second class, not so well known to the general public, have still a considerable application, for example, lead soap, or plaster of pharmacy, alumina soap used as a lubricant, and iron and chromium soaps used in dyeing and printing.

* For Bibliogrphy, see p. 297.

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There are two general classes of soaps, the potash or soft soaps, so called in virtue of their property of absorbing water and remaining in a semi-fluid or pasty condition and the soda or hard soaps which lose water and become quite hard or horny in character on exposure to the atmosphere. The potash soaps, though formerly much prized, have almost entirely gone out of use, the chief reasons being their property of absorbing water, rendering them unsuited for keeping and transportation, and the greater cost of the alkali. Furthermore, though they are invaluable for certain purposes, as the scouring of raw wool and rough household use, the extreme difficulty of making a neutral compound makes them unsuited for use in the toilet and general cleansing of clothing or other objects, for which soap has so important an application.

With these brief remarks we may then dismiss the subject of soft soaps, since the methods of preparation are similar and the analysis exactly like that of the more important soda compounds.

The fats usually employed in making hard soaps may be the neutral fats, *i.e.*, the glycerides, compounds of fatty acids with glycerine, or the fatty acids themselves.

The neutral fats most commonly used are stearin, palmitin, olein and laurin or cocoanut oil, and as fatty acid, oleic acid, the stearic and palmitic acids being chiefly used for the fabrication of candles. As a rule, better products can be obtained by using the neutral fats.

Thirty-one parts of soda ($Na_2O$), or one-half the molecular weight, require for combination the following quantities of the common fat acids:

| | Parts. |
|---|---|
| Stearic acid, | 284 |
| Oleic acid, | 282 |
| Palmitic acid, | 252 |
| Lauric acid, | 200 |

One hundred parts of the following fats require the following amounts of alkali for complete saponification:

| | Potash. | Soda. |
|---|---|---|
| Olein, | 15.95 | 10.52 |
| Palm oil, | 16.67 | 11. |
| Tallow, | 15.92 | 10.50 |
| Cocoanut oil, | 18.86 | 12.44 |

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Soda soaps may be classed as follows:

Toilet Soaps.—Pure soaps, containing no rosin, free or carbonated alkali or silicate.

Household Soap.—Containing rosin and free and carbonated alkali and silicate not to exceed one-half of one per cent.

Manufacturer's Soaps.—Strongly alkaline soaps with or without rosin or silicate as the special case may require.

Medicated Soaps.—Pure soap containing phenol, naphthol or other medicinal agent.

Salt Water Soaps.—Mixed soda and potash soaps of cocoanut oil which are soluble in both fresh and salt waters.

Soaps may be prepared from oleic acid by direct combination with soda, preferably the carbonate, in the cold or at a slightly elevated temperature, but the best results are obtained when the glycerides are saponified with successive portions of rather dilute caustic soda, using the weakest solution first and boiling after each addition; when complete the soap is separated by adding a strong brine and rises to the surface, allowing the mass to cool, the soap is skimmed off and placed in frames; such a product is called *curd* soap. For household soaps containing rosin it is usual to add this substance gradually in the form of a fine powder during the process of saponification. Some makers prefer to saponify rosin and fats together, but the best method is to add the rosin to the soap in the form of a soda resinate.

There is much dispute as to the value of rosin in soaps of this character; soapmakers claim that it renders the soap more lasting and yields a finer lather, on the other hand, if present in too large proportion it coats the skin with a thin film of rosin and renders fabrics yellow and sticky, in any event it should not exceed 25 per cent. of the total fatty acids present as soap.

A curious system in vogue among soapmakers should be noted. Rosin soaps are rated according to the proportion the rosin bears to the fatty acids present; a soap of equal parts of rosin and fat is called 100 per cent. rosin; one-quarter rosin, three-quarters fat, is 50 per cent. rosin; three-quarters rosin and one-quarter fat is 150 per cent., etc.

Little if any curd soap is sold as such; additions of various substances, in the main deleterious, are made in the subsequent operation of *crutching*. This process consists in reducing the curd soap to a mass of fine shreds, at the same time incorporating with



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it sal soda or silicate, or both, and thoroughly mixing the mass. These agents increase the detergent action, but the addition of such materials as clay, wood-pulp, barytes, etc., is indefensible. All the above materials have the very significant name of *fillers*.

A pure soda soap has the following composition:

| | Per cent. |
|---|---|
| Fatty acids, | 62.3 |
| Water, | 32.8 |
| Combined alkali, | 6.7 |
| Salts, | 0.2 |

A soda rosin curd soap just from the pans analyses as follows:

| | |
|---|---|
| Fat and rosin acids, | 65. |
| Soda, | 6.5 |
| Water, | 28.5 |

The following are good examples of rosin soaps:

| | 1. | 2. | 3. |
|---|---|---|---|
| Fats and rosin, | 70.0 | 60.43 | 61.0 |
| Water, | 23.5 | 32.50 | 32.8 |
| Soda, | 6.5 | 6.77 | 6.2 |

As a rule the combined alkali is one-ninth of the fat existing as soap.

## Analysis of Soap.

Analysis of soap.

Determination of water, etc.

Cut from a bar of soap several one-half inch cubes, place in a clean dry test tube, cork and weigh the whole. Then shake from the tube 2 or 3 cubes (5 to 10 grammes) into a platinum dish containing 25 or 30 grammes of clean, dry sand and a small glass rod, all of which have been previously weighed; now add 50 to 75 c.c. of absolute alcohol and heat on the water bath until the soap is dissolved, stirring at intervals. Evaporate the solution slowly to dryness, mixing the contents of the dish thoroughly as the mass dries, then transfer to an air bath at a 100° C. Remove from the air bath, cool and weigh, repeat the operation to constant weight. The loss is water.

Or 5 grammes of soap may be weighed in a platinum dish with a small glass rod, the dish and contents heated over a low flame with constant stirring; the temperature should not be allowed to rise high enough to burn the soap; a clean cold glass plate held

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over the dish for a few moments will show by the presence or absence of moisture whether or not the water has been driven off. This operation takes about twenty minutes, and is accurate to 0.25 per cent.

Instead of using a platinum or porcelain dish a better way is to make use of a shallow lead dish 2½ or 3 inches in diameter; large bottle caps serve very well. The same routine is passed through in determining water; when this is done the dish and contents may be bent up and placed in the inner tube of an extraction apparatus, preferably the Knœffler, and after filling the tared flask with petroleum ether the apparatus may be put together and run for one to two hours; at the end of this time the apparatus is cooled, the lead dish removed and replaced by a short test tube, the apparatus again closed and set in operation continuing until nearly all the petroleum ether has distilled from the flask. The apparatus is again cooled, the tared flask removed and laid on a hot water bath on its side until all odor of petroleum ether has disappeared; it is then cooled and weighed; the increase represents unsaponified fat. The dish is again replaced in the extractor and treated with 95 per cent. alcohol to remove the soap and glycerine; one and one-half to two hours time will effect this result. The dish and contents are now removed from the extractor, placed in a medium sized beaker and treated with hot water, finally filtering and washing until free from chlorides; the filtrate is diluted to 400 c.c. and 100 c.c. taken for the determination of $Na_2CO_3$, 100 c.c. for $Na_2SO_4$, 100 c.c. for NaCl, 100 c.c. for silicate. The residue insoluble in $H_2O$, may be examined for mineral colors, insoluble soaps, clay, wood pulp, silica, etc.

The alcoholic solution of the soap is now removed from the flask, adding more alcohol if necessary, and a few drops of phenolphthalin added, and titrated for free alkali with N10HCl. (N. B. It has frequently been observed that a soap may contain free alkali and uncombined fat, an apparent anomaly, the result, however, of careless manufacture.) The alcohol may now be removed from the soap solution by diluting with $H_2O$ and passing through it a current of steam. When this has been effected add an excess of N/HCl to decompose the soap; boil the resulting mass for ten to fifteen minutes (after adding a strong solution of NaCl or $Na_2SO_4$ to render the fatty acids of cocoanut oil, etc., insoluble), chill the fatty acids, punch two holes through the cake and decant the solu-

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tion through a filter, add some hot water to the fat acids in the beaker and more NaCl if necessary and wash, chill, filter as before; finally break up the cake of fat acids, transfer to the filter, dry the beaker, rinse out with ether into a tared flask, introduce the filter paper and contents into an extraction apparatus and extract the fat and resin acids, drive off the ether, heat gently, cool and weigh. It is sometimes necessary to determine resin; in this case use the methods of Gladding or Twitchell.

The watery solution is now titrated with $N/_5KOH$ to determine the excess of acid used. When the neutral point has been reached, note the number of cubic centimetres used, add two or three drops of methyl orange and again titrate until neutral; this last result is the amount of soluble fatty acids and should be added to the other figures. Finally calculate results and report as follows:

Water.
Fatty and resin acids.
Combined alkali, $Na_2O$.
Free alkali, NaOH.
Alkali carb., $Na_2CO_3$.
Alkali silicate.
NaCl.
$Na_2SO_4$.
Mineral matter.
Fatty and resin anhydrides.
Actual soap.

## Determination of Rosin.

Gladding's method for the determination of rosin depends upon the fact that silver resinate is quite soluble in (ethyl) ether, while the silver compounds of the fat acids (with a partial exception in the case of the oleate) are but slightly so. (*Am. Chem. Jour.*, iii., 416.) Dissolve about 0.5 gramme of the mixed fat acids and resin in 20 c.c. of strong alcohol, and add a slight excess of soda solution, using phenolphthalein as indicator. Boil for a few minutes to insure complete saponification, cool and mix with ether in a graduated cylinder (stoppered) making bulk up to 100 c.c. To this solution add 1 gramme of finely powdered $AgNO_3$ and shake well for ten minutes or more. After settling draw off 50 c.c. of the solution (filtering if necessary) into another cylinder. Insure complete precipitation by again adding a little powdered

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$AgNO_3$ and shaking. Then add 20 c.c. of dilute HCl (1 : 2) to decompose the silver resinate. Allow to settle and then draw off an aliquot part of the ethereal solution and evaporate in a tared dish. From the weight of resin and oleic acid thus obtained deduct 0.00235 gramme (oleic acid) for every 10 c.c. of solution taken. The remainder represents *resin*.

Twitchell's method for estimation of rosin in its mixtures with fatty acids.* When fatty acids are dissolved in absolute alcohol and treated with hydrogen chloride, their ethereal salts are formed. Rosin treated in the same way undergoes no change. On this principle the author has based his process, which may be conducted either gravimetrically or volumetrically. The gravimetric method is carried out as follows: 2 or 3 grams of the mixture of fatty acid and rosin is dissolved in ten times its volume of absolute alcohol, and dry hydrogen chloride is passed through in a moderate stream, the flask being placed in a vessel with water to keep it cool. The gas is rapidly absorbed, and after about 45 minutes the ethereal salts separate and float on the solution. After waiting for half an hour longer, the liquid is diluted with five times its bulk of water and boiled until the acid solution is clear, the ethereal salts, with rosin in solution, floating on top. To this is added some light petroleum, and the whole transferred to a separating funnel, the flask being washed out with light petroleum. The acid liquid is then run off, and the light petroleum solution washed once more with water and then treated in the funnel with a solution of 0.5 gram of potassium hydroxide and 5 c.c. of alcohol in 50 c.c. of water. The rosin is immediately saponified, and the two layers separate completely. The rosin soap solution can then be run off, and the rosin recovered, as usual, by the addition of an acid. The first stages of the volumetric method are similar to those of the gravimetric, with the exception that the contents of the flask are washed into the separating funnel with ether instead of light petroleum, and the ethereal solution is then thoroughly washed with water until all soluble acidity is removed. 50 c.c. of neutral alcohol is then added, and the solution titrated with standard solution of sodium hydroxide. The test analyses are satisfactory.

A few explanatory notes should be added:

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* From *J. Anal. and Appl. Chem.*, 5, 379.

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In the case of transparent soaps, and possibly some others, the loss by drying at 100° C., though usually reckoned as water, may be partly alcohol. Drying at 120° will drive out essences (perfume) as well as water. To some soaps Carnaüba wax and vaseline or products from petroleum are sometimes added. The effect of the Carnaüba wax is to conceal the presence of the petroleum's compounds by rendering them soluble in alcohol or in water.

Qualitative tests for free alkali or alkali carbonate in soap may be made by touching a freshly cut surface with a drop of phenolphthalein solution or of mercuric chloride. The former gives a purplish-red spot, the latter a brownish or reddish spot if either are present. If not the spot is white.

For glycerine Muter's copper test is frequently used. (*Analyst*, vol. 1, 41.) It depends upon the principle that glycerine (in common with many other organic substances) will prevent the precipitation of a certain proportion of cupric hydrate by alkaline hydrate. To the aqueous solution freed from fat acids a strong solution of potassium hydrate is added, and then dilute $CuSO_4$ solution until a fair amount of insoluble cupric hydrate remains insoluble. The solution is made up to a known bulk, well shaken and set aside to settle; an aliquot portion is then drawn off, a very slight excess of $HNO_3$ added, and then a known volume of ammonia, and the solution titrated with KCy. The results are compared with similar results obtained on a solution containing a weighed amount of glycerine.

In the examination of that portion of the soap insoluble in alcohol the titration of the water solution therefrom with $N/_2$ (or $N/_{10}$) acid, using methyl orange as indicator, will give the soda combined as carbonate, borate and silicate in the soap.

Transparent soaps, sometimes sold as "glycerine" soaps, may contain much cane sugar and practically no glycerine. The cane sugar may be determined by inversion with acid and using the Fehling test. In such cases the proportion of water is usually lower than with genuine glycerine soaps.

Gelatin, if present in soap, may be determined in the portion insoluble in alcohol, by combustion with soda lime, or applying the Kjeldahl method for nitrogen.

In calculating the results of the analysis it must be remembered that in the soap the fatty anhydrides are combined with sodium, whereas in the process of analysis these are determined as fatty

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WILLIAM G. PECK,

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acids and soda respectively. The result is that the sum of the fat acid and soda obtainable from a soap is two or three per cent. more than the actual weight of the soap. To get approximately the fatty anhydrides the weight of the fat acids is usually multiplied by 0.97. It is best to report the percentages of both fat acids and fatty anhydrides.

Table of analyses of some American soaps made by the author.

Fresh water soaps:

| | (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) |
|---|---|---|---|---|---|---|---|
| Fats and rosin, . | 53.87 | 66.24 | 59.6 | 65.7 | 69.54 | 61.9 | 70.38 |
| Free alkali, . . | —— | 0.36 | —— | —— | —— | —— | —— |
| Combined alkali, . | 6.17 | 6.82 | 6.05 | 6.66 | 7.67 | 6.62 | 7.56 |
| Alkali carbonate, . | 2.57 | —— | 2.8 | —— | —— | 3.51 | 0.17 |
| Water, . . . | 36.33 | 28. | 28.13 | 26.82 | 24 55 | 27.44 | 16.96 |

Nos. 2, 4, 5 are good, 1, 3 and 6 are poor.

Salt water soap:

| | (1.) | (2.) | (3.) |
|---|---|---|---|
| Water, . . . . . | 25.5 | 53.49 | 46.05 |
| Combined alkali, . . . . . | 7.84 | 5.23 | 7.04 |
| Alkali carbonate, . . . . . | 1.36 | 4.61 | 7.27 |
| Fats (cocoanut oil), . . . . . | 61 25 | 34.14 | 45.99 |

No. 1 is a tallow soap and would not wash in salt water.

No. 2 is a standard salt water soap.

No. 3 consists of cocoanut oil and tallow.

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## PROFESSOR WILLIAM G. PECK.

"WILLIAM GUY PECK, born in Litchfield, Ct., October 16, 1820; died in Greenwich, Ct., February 7, 1892. For thirty-five years Professor in Columbia College, New York." Such is the tenor of the inscription which Professor Peck, whose heart was wrapped up in Columbia and the work in which he was there engaged, desired to have engraved upon his monument.

William G. Peck, or Guy Peck, as he was known at West Point and by his more familiar friends, entered the United States Military Academy July 1, 1840. He soon won a commanding posi-

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tion among his fellows, which he maintained throughout his cadetship. He was graduated July 1, 1844, at the head of his class, which contained, among others, Alfred Pleasanton and Winfield S. Hancock, afterwards distinguished generals in the late Civil War. On graduation he was assigned to the Corps of Topographical Engineers. During the eleven years of his connection with the army, he assisted in the military survey of Portsmouth Harbor, N. H., 1844–5, accompanied Fremont's third exploring expedition through the Rocky Mountains, 1845, was attached, during the war with Mexico, 1846–7, to the Army of the West, under Brig.-Gen. Stephen Kearney (who was educated at Columbia, but joined the army for active service in 1812 and was not graduated), and served as Assistant Professor of Mathematics at the Military Academy, 1847–55. He resigned from the army October 2, 1855.

An incident connected with the exploring expedition is worthy of note. The party was attacked by Indians. Lieutenant Peck, while directing operations in his part of the field, was holding his hand, in which was a pistol ready for use, close to his breast, when a sharp blow nearly knocked the weapon from his grasp. Something fell at his feet, which, on examination, he found to be an Indian bullet, with the date of manufacture and a part of the name of the maker of his pistol embossed upon its flattened surface. The bullet is still preserved as the memorial of his narrow escape from death in battle, and is now in the possession of Professor Trowbridge.

As with poets, so with teachers; they are born, not made. Professor Peck was a born teacher. His aptitude and capacity in this regard were early recognized and availed of by his *Alma Mater*. By far the larger part of his time in the military service was spent in teaching mathematics to the cadets at West Point, where he had among his pupils some of those who subsequently did conspicuous service in the War of the Rebellion, as Generals Slocum, Stanton, Webb, Warren, Howard, Schofield, Sheridan.

On leaving the army, he became Professor of Physics and Civil Engineering in the University of Michigan, at Ann Arbor, which post he resigned to become Adjunct Professor of Mathematics in Columbia, July 1, 1857. The time at which he came to Columbia was an important one. The College had, a year or two before, acquired the means to extend its operations. It added to its

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faculty several able men, as Francis Lieber, Charles Murray Nairne, Charles Davies, William G. Peck. A university course of study was projected, and Professor Peck entered heartily into the scheme. He volunteered to give courses in engineering in all its branches, and, in the winter of 1858, gave courses in civil engineering, in addition to his regular college courses in mathematics. When the School of Mines was opened in 1864, he took charge of the department of mechanics, and remained at its head till the day of his death; he is therefore entitled to consideration as one of the original promoters of the prosperity of that great school. On the death of Professor Hackley, in 1861, the department of astronomy was also entrusted to him; so that his official record in Columbia College is: Adjunct Professor of Mathematics, 1857–9; Professor of Mathematics, 1859–61; Professor of Mathematics and Astronomy, 1861–92; Professor of Mechanics, School of Mines, 1864–92.

He received the degree of Master of Arts from Trinity College, Ct., in 1853, and the degree of Doctor of Laws from the same institution in 1863. Columbia made him a Doctor of Philosophy in 1877. He was the author of numerous works, including a mathematical dictionary, and text-books in arithmetic, algebra, geometry and trigonometry, differential and integral calculus, determinants, mechanics, physics, and astronomy. His works are characterized by lucidity, conciseness and directness. His teaching was distinguished by the same excellent qualities. His full and exact knowledge of the subjects which he taught, his clear exposition and illustration of them, his enthusiasm, his solicitude for the advancement and welfare of the students, the humor with which he occasionally illumined his lectures, made his room an attractive one, and his courses sought after and enjoyed. It is within the personal knowledge of very many, perhaps the most, of those by whom this notice will be read, that no professor in the college was more beloved than he.

In the blizzard of March, 1888, Prof. Peck, in attempting to get to New York from his home in Greenwich, suffered great hardship and privation, that probably did him permanent injury. In the winter of 1891, he had a severe attack of the grip, from which he did not fully recover. Latterly and for several years his strength had been failing; he had alternations of better and poorer health, but at no time good health, and was sometimes at his post when

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prudence should have kept him at home. He sturdily discharged his duty, however, and finished the mid-winter examinations of the present academic year. On leaving the College after the last of his examinations, he thought he might remain away long enough to recuperate.

He was proud, as he might well be, of his military training. He undertook any responsibility legitimately put upon him without a murmur; he obeyed promptly and cheerfully any order issued by authority. He was a soldierly man. After a consultation of physicians upon his case a short time ago, he was informed that though seriously ill, he might recover sufficiently to go about and still enjoy life. He drew himself up and remarked to his wife: "When General Brady was told that he had but a few days to live, he said, 'General Brady's knapsack is slung and he is ready for the march.'"

On the Friday before he died he expressed a desire to see Mr. Low. On Sunday afternoon, the 7th inst., the President went to Greenwich to visit him. In the evening of that day, at half-past seven o'clock, while conversing cheerfully with Mrs. Peck and the President, he suddenly put his head back, stretched out his hand to his wife, and breathed his last. He was gone in a moment.

On the Wednesday following, a bright and beautiful day, dressed in his academic robes, as he expressly desired, accompanied by his family and his neighbors, by president, professors, alumni, and students of Columbia, he was borne to the parish church at Greenwich; after the beautiful funeral service of the Episcopal Church, he was taken thence to rest among his kindred in Litchfield, where, more than threescore and ten years ago, he began his long, honorable, and useful life.

"Now the laborer's task is o'er;
Now the battle day is past;
Now upon the farther shore
Lands the voyager at last.
Father, in Thy gracious keeping
Leave we now Thy servant sleeping."

Feb. 11, 1892. J. H. VAN AMRINGE.

—In *Columbia Spectator* of February 18, 1892.

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# ABSTRACTS.

## MINERALOGY, BY A. J. MOSES.

ADELITE, *Sjögren.* $H_2Mg_2Ca_2As_2O_{10}$.

Gray masses, H = 5; C = 3.76; from Nordmark and Langban.—Abstract in *Amer. Journ. Sci.*, xliii., 246.

AMPHIBOLE (GRUNERITE).

Lane and Sharples state that the peculiar colorless to slightly green or brown amphibole with high silky lustre, found with certain iron ores at Lake Superior, which has been called variously actinolite and anthophyllite, is a ferro-magnesian monoclinic variety corresponding closely to grünerite.—*Amer. Journ. Sci.*, xlii., 505, December, 1891.

ANALCITE.

Effect of heat upon optical properties.—C. Klein, *Neues Jahrb. f. Min.*, 1891, i., 93.

ANORTHITE, *from Japan.*

Anorthite crystals are found as a primary constitutent of the lava from the volcano on the Island of Miyake, and have also been brought from other islands of the Shichito group. The Miyake crystals are frequently found scattered over the lava surface, showing that they were ejected from the volcano as well defined crystals; they vary from $\frac{4}{10}$ to 1.6 inches in their longest direction, and are always covered with a black or reddish colored thin spongy crust of lava. The interior of the crystals is usually transparent and vitreous, though some specimens show a slight decomposition. Cleavage is perfect parallel to OP, and less perfect parallel to $\infty \breve{P} \infty$ always showing twin striæ. Chrysolite grains are always inclosed, often arranged in distinct zones, and glassy inclosures parallel to some crystal direction are frequent. Single crystals are rare; penetration twins, analogous to the Carlsbad type in Orthoclase, twinning axis c, composition plane $\infty \breve{P} \infty$ are frequent. Twin lamellæ of the pericline type, twinning axis $\bar{b}$, occur.

G. 2.761. Fusible with difficulty to a clear glass. Soluble in HCl with gelatinous residue. Analysis shows:

| | Miyake. | Tonosawa. |
|---|---|---|
| $SiO_2$, | 44.03 | 44.16 |
| $Al_2O_3$, | 36.80 | 31.87 |
| $Fe_2O_3$, | | 1.33 |
| CaO, | 19.29 | 20.90 |
| MgO, | .20 | .53 |
| $Na_2O$, | .23 | .32 |
| $K_2O$, | | .55 |
| $H_2O$, | .12 | .60 |
| | 100.67 | 100.26 |

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The lava in which they occur is usually porous, sometimes compact. The principal ingredients are anorthite crystals and rounded, rarely crystallized, olivine grains coated with hematite; in a ground mass of micro-crystalline felspar and magnetite with some micro-crystals of apatite and a brownish glass of anorthite, olivine and augite. The order of crystallization was probably apatite, magnetite, olivine, anorthite and augite.—Prof. Kikuchi, *Journal of College of Science*, Imperial University, Japan, vol. ii., pp. 31–47.

ANTLERITE, *Hillebrand* ($3\ CuSO_4, 7\ CuOH_2$).

Found at Antler Mine, Yucca Station, Mohave county, Arizona, massive light green. G = 3.93.—Bulletin 55, *U. S. Geol. Surv.*, p. 54, 1889.

ARAGONITE.

Gonnard records the faces found upon the aragonite crystals from the tunnel of Neussargues, Cantal.—*Bull. Soc. Franc. Min.*, 1891, xiv., 183.

Beckenkamp's study of Bilin crystals.—*Zeit. f. Kryst.*, xix., 241–264; xx., 163.

ARSENOPYRITE.

Crystalline form and constitution.—Weibull, *Zeit. f. Kryst.*, xx., 1–25, 1892.

ASTOPHITE, *Sjögren.*

Violet and blue coarsely crystalline material from Langban, Sweden; cleavage, 56° 27′; G., 3.05–3.10.—Abstract in *Amer. Jour. Sci.*, March, 1892, xliii., 246.

ATACAMITE, of Chili.

L. Darapsky, *Neues Jahrb. f. Min.*, 1889, ii., 1–18.—Abstract *Zeit. f. Kryst.*, xx., 100, 1892.

BARITE.

Banded crystals from Pettes Co., Mo.—Wheeler and Luedeking, *Amer. Journ. Sci.*, xlii., 495, 1891.

Gonnard records the crystalline forms found at various localities in Puy-de-Dome, Auvergne.—*Bull. Soc. Franc. Min.*, 1891, xiv., 174.

Crystals of Sugana Valley Tyrol.—*Zeit. Kryst.*, xx., 170 and 176.

BERTRANDITE.

Recorded from Mercerie. Commune of La Chapelle-sur-Erdre, Loire-Inferieure.—*Bull. Soc. Franc. Min.*, 1891, xiv., 189.

BERYL.

Bluish-green variety, from St. Ilario, Elba, described by Bussatti, *Giornale di Mineral*, ii., 278.

Optical anomalies of Beryl.—Karojitsky, *Zeit. f. Kryst.*, xix., 209–219, 1891.

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BLOEDITE, *of Pampa del Toro, Tarapaca, Chili.*

Purest white with numerous crystal faces. Analysis (mean of two) showed:

$SO_3$ 47.79; MgO 11.98; $H_2O$, 21.60; $Na_2O$ (by Diff), 18.53.

—*Zeit. f. Kryst. u. Min.*, 1891, xix., 446.

BOLEITE, *Mallard and Cumenge.* $3[PbClOH.CuClOH] + AgCl.$

At the copper region of Boleo, near Santa Rosalie, Lower California, beautiful indigo blue cubic crystals and smaller crystals in octahedral groups have been found disseminated in a reddish or greenish clay-like gangue which overlies the copper deposit.

The crystals are frequently implanted on anglesite and accompanied by phosgenite in little prismatic crystals, atacamite and cerussite.

Very remarkable crystallographic characters are described. The usual

FIG. 1.

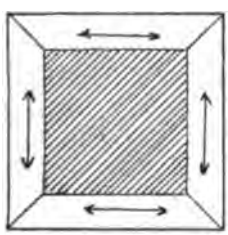
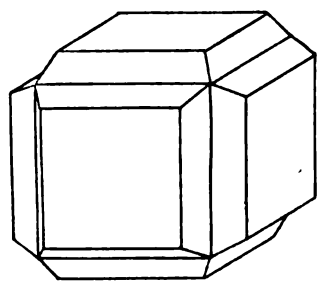


FIG. 2.



form is the cube modified in a few instances by the octahedron and rhombic dodecahedron. Easy cubic cleavage and difficult octahedral

FIG. 3.

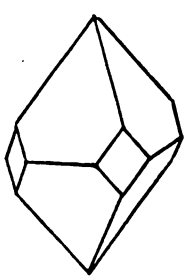


FIG. 4.

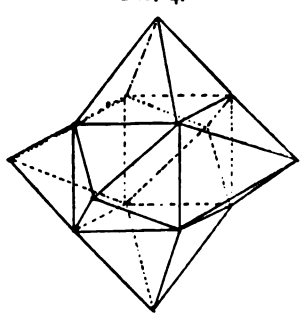
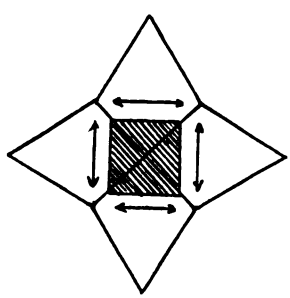


FIG. 5.



cleavage exist. Thin sections parallel to a cubic face, are found to be centrally isotropic with a doubly refracting border, the smaller index of refraction being in the direction of the arrows (Fig. 1). A section at the cube surface is composed entirely of one of these doubly refracting portions, but is isotropic in the centre, and shows with convergent light the rings and black cross of a negative uniaxial crystal. A small number

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of pyramidal crystals are found, sometimes isolated (Fig. 3), but often in groups of three, with their principal axes at right angles to each other (Fig. 4). A section of such a group (Fig. 5) shows an almost isotropic central portion.

The curious anomalies are explained if the mineral is assumed to be tetragonal and the axis ratio c = 0.9873. The cube then corresponds to three crystals inter-penetrating with their quaternary axes parallel to the quaternary axes of the cube, and united to each other parallel to planes of the pyramid [011] 1-i, and terminated by the basal plane [001] 0. Less frequently there appears also the pyramid [021] 2-i. Fig. 2 and the pyramid, [053] $\frac{5}{3}$-i, Fig. 4.

The mineral differs from Groth's formula for percylite only in the AgCl. The name boleite is therefore only provisional.—Mallard and Cumenge, *Compte Rendu de l'Acad. des Sciences*, Oct. 26, 1891, and *Bull. Soc. Franc. Min.*, xiv., 293, Dec., 1891.

BOURNONITE, of Nagybánya.

A. Schmidt, *Zeit. f. Kryst.*, xx., 151, crystallographic study.

CALCITE.

Crystals from Nieder Rabenstein, Saxony. Beckenkamp.—*Zeit. f. Kryst.*, xx., 165.

Crystals from various localities, *Zeit. f. Kryst.*, xix., 321, 335, 1891.

Crystals of Vorarlberg, *Tschermak*, xii., 171, Blumrich.

CASSITERITE.

R. H. Solly describes the variety "sparable" (sparrow-bill?) tin from Cornwall, which occurs always in sharply pointed crystals, with the ditetragonal pyramid (3 2 1) $3P\frac{8}{2}$ largely developed, with a long, striated prism. The forms as observed by various mineralogists are recorded, and crystals from many mines are described.—*Mineralogical Magazine*, ix., 199–208, March, 1891.

CELESTITE.

Crystals of Scharfenberg, Saxony, described by J. Stuber.—*Zeit. f. Kryst. u. Min.*, 1891, xix., 437.

CERUSSITE, of Sardinia.

Summary of crystallographic study by Artini.—*Zeit. f. Kryst.*, xix., 314, 1891.

Cerussite of Auronzo, similar study by Negri.—*Ibid.*, 319.

CHABAZITE and PHACOLITE.

Optical structure and behavior when heated.—C. Klein, *Neues Jahrb. f. Min.*, 1891, i., 96.

CHEMAWINITE, *Harrington.*

The so-called amber of Cedar Lake, North Saskatchewan, Canada, is classed provisionally by Harrington with the retinites because nearer to

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krantzite, walchowite, etc., than to succinite (true amber). Composition given is: C, 80.03; H, 10.47; 9.50.—*Amer. Jour. Sci.*, xlii., 332, 1891.

CHLORITOID.

Lane and Keller describe chloritoid from the Champion Iron Mine, Michigan, and other localities, and reach the conclusion that "All the Michigan chloritoids, as well as the masonite (of Natick, R. I.), a chloritoid from Pregratten, one from Leeds, Canada, and one from the Appenines, appear to be optically the same; they have the usual trichroism and are pronouncedly triclinic." All "contain constitutional alkali." Ottrelite from Ottrez seems to be optically, as well as chemically, different.—*Amer. Jour. Sci.*, xlii., 500, December, 1891.

CHRISTOBALTITE.

Lacroix records the second known occurrence of this mineral in the quartzoze enclosures of the basalt of Mayen, Rhenish Prussia. It is associated with tridymite.—*Bull. Soc. Franc. Min.*, 1891, xiv., 185.

DARAPSKITE, *Dietze*, $NaNO_3$, $Na_2SO_4+H_2O$. *Tetragonal.*

Found in great quantity at Pampa del Toro, Tarapaca, Chili. Beautiful, water-clear, transparent, tetragonal plates, the sides of which are composed of several pyramids, too small to permit angle measurements. This is the first crystallized double salt of $NaNO_3$ and $Na_2SO_4$ the nitroglauberite of Schwartzenberg being amorphous $4Na_2SO_4 + 6NaNO_3 + 5H_2O$. Analyses of the two are as follows:

| | Darapskite. Dietze. | Nitro-glauberite. |
|---|---|---|
| $N_2O_5$, | 32 88 | 38.31 |
| $SO_3$, | 22.26 | 19.09 |
| $Na_2O$, | 38.27 | 36.83 |
| $H_2O$, | 7.30 | 5.75 |
| | 100.71 | 99.98 |

Named after Dr. L. Darapsky.—*Zeit. f. Kryst. u. Min*, 1891., xix., 445.

DIAMOND.

Occurrence in the meteorite of Cañon Diablo, Arizona, proved by Koenig.—*Amer. Jour. Sci.*, xlii., 415, November, 1891.

ELATERITE.

The so-called elaterite of Kutais, Russia, is by analysis C. 51, H. 4.60, O + N 34.57, ash 9.66 = 100. Hygro. water, 7.28, or a dopplerite. Pure elaterite the author considers to be merely asphalt $n(CH_2)$, with a little intermixture of oxygen compounds. A specimen from Sakupris, Kutais, yielded C. 84.66, H. 8.19, O + N 4.98, ash, 2.19 = 100.62. —W. Alexejew, *Zeit. f. Kryst.*, Abstracts, xx., 187.

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EUCAIRITE, $AgCuSe$.

Found in limestone on the western slopes of the Sierra de Umango, Province of La Rioja, Argentina.—*Zeit. f. Kryst.*, xix., 265, 1891.

FOOTEITE, *Koenig*, $8Cu(OH)_2$, $CuCl_2 + 4H_2O$. *Monoclinic.*

Associated with the new mineral paramelaconite from Copper Queen Mine, Arizona, were small monoclinic needle crystals of a beautiful indigo-blue color. The usual faces, prism, clino-pinacoid, clino-dome and pyramid, give an hexagonal appearance to the crystals. The prism-angle is 49°. In closed tube become black, with brilliant lustre, and yield water. Color the flame blue and green. On coal melt to a white slag and yield metallic copper. Easily soluble in acids. Analysis showed:

| | |
|---|---|
| $CuO$ | 63 7 |
| $CuCl_2$ | 13.5 |
| $H_2O$ | 22.8 |

—*Zeit. f. Kryst.*, 1891, xix., 601.

GANOPHYLLITE, *Hamberg*, $Mn_7Al_2Si_8O_{26}$, $6H_2O$. *Monoclinic.*

Found at Harstig Mine, Sweden, in brown monoclinic crystals, with perfect basal cleavage. H., 4 — 4.5; G., 2.84.—*Amer. Journ. Sci.*, xlii., 433, 1891.

HEMATITE, of Stromboli.

Crystallization by Strüver.—*Zeit. f. Kryst.*, xx., 174.

HYALOPHANE.

White crystalline material in crevices of the Buntsandstein of Steinberg, near Waldau, corresponded to the barium feldspar. Quantitative analysis not made.—v. Sandberger, *Neues Jahrbuch f. Min.*, 1891, i., 67.

ILVAITE.

From Barclay Sound, Vancouver Island, B. C., in large, irregular masses in a twenty-foot wide vein.—*Amor. Journ. Sci.*, xlii., 432.

IODOCHROMATE, *Dietze*, $7Ca(IO_3)_2$, $8CaCrO_4$. *Orthorhombic?*

In the vicinity of the lautarite, in the saltpetre pampas of Lautaro, Chili, are found small, imperfectly formed, dark-yellow crystals, apparently rhombic prisms. Slightly soluble in water, with recrystallization of flat plates of $Ca(IO_3)_2 + 6H_2O$, while $CaCrO_4$ remains in solution. —*Zeit. f. Kryst.*, 1891, xix., 449.

IOLITE.

O. C. Farrington concludes, from careful examination of exceptionally pure iolite from Guilford, Conn., and from re-examination of less pure material from Haddam, Conn., that the iron is ferrous and the water constitutional, and deduces the formula, $H_2O$, $4(Mg.Fe)O$, $4Al_2O_3$, $10SiO_2$.—*Amer. Journ. Sci.*, xliii., 13, January, 1892.

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IRON.

Native iron is reported in the virgin auriferous gravel from the valley of a branch of the Ribeira, Southern Brazil.

JEREMEJEFFITE.

Optical properties and behavior under heat and pressure.—C. Klein, *Neues Jahrb. f. Min.*, 1891, i., 84.

LAUTARITE, *Dietze*, $Ca(IO_3)_2$. *Monoclinic.*

Found in the saltpetre region of "Pampa del Pique III.," and other neighboring pampas of Lautaro, Chili, and also in Pampa Grove, Catalina. It appears to be limited to the chloride of lime pampas.

Occurs in beautifully formed monoclinic crystals, often very large, with well developed prism faces and occasionally the basal plane. The prism angles measured 83° 30′. The best shaped crystals are found at the greatest depths, either bedded in gypsum or placed directly in clefts in the bed rock in radial star-like aggregates. Analysis showed I, 64.66 (mean of two) = $I_2O_5$—79.96, CaO 14.95. Lautarite is clear, transparent, usually of a yellow color. G. 4.59; very slightly soluble, easily dissolved by heating with $Na_2SO_4$ or $Na_2CO_3$ with residue of $CaSO_4$ or $CaCO_3$—*Zeit. f. Kryst.*, 1891, xix., 447.

LUZONITE.

Klockmann restudies this material on specimens from Sierra de Famatina, Argentina, and agrees with Weisbach that it connects Enargite, $Cu_3AsS_4$, and Famatinite, $Cu_3SbS_4$, being isomorphous with the latter and of same composition as the former.—*Zeit. f. Kryst.*, xix., 272, 1891.

MAGNESIOFERRITE.

Lacroix finds that certain octahedral crystals from Rock of Cuzeau, Mont Dore, Puy de Dome, always called martite, are composed mainly of inter-crossed, flattened crystals of hematite; the octahedral mineral, however, appears to have been magnesioferrite, not magnetite, as after precipitation of all iron there remains a considerable amount of magnesia.—*Bull. Soc. Franc. Min.*, xv., 11, Jan., 1892.

MARCASITE.

Intergrowth with pyrite, so that each face of the cube carries a marcasite twin, the twin face being perpendicular to the cube face and parallel to the striations upon it, and the vertical and one lateral axis of the marcasite being parallel to two principal axes of the cube.—Trechmann, *Min. Mag.*, ix., 209, March, 1891.

MELANOPHLOGITE.

Streng believes that this curious silica contains sulphide of silicon, not sulphuric acid. Treated with strong concentrated HFl, it evolved $H_2S$, noticed by both smell and lead paper reaction. Whether it is a chemical combination of $SiO_2$ and $SiS_2$, or a mechanical mixture of



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$SiS_2$, surrounded and protected from the decomposing action of water by $SiO_2$, the author is uncertain, but inclines to the latter view.—*Neues Jahrb. f. Min.*, 1891, ii., 211.

MORINITE, *Lacroix*, $Al_2O_3, Na_2O, P_2O_5, H_2O$ ? Monoclinic.

A rose-colored mineral found at Montebras, France, often intimately mixed with amblygonite and supposed to have been formed from it, has been named morinite by Lacroix after M. Morineau, the director of the mine at which it was found. The material before the blowpipe swells and melts to a cauliflower-like mass. In the closed tube it loses rapidly about 13½ per cent. of very acid water, which attacks the glass. It is soluble in acids, and the solutions react for alumina, soda and phosphoric acid. Microscopic monoclinic crystals were found.—Lacroix Preliminary Notice, *Bull. Soc. Franc. Min.*, 1891, xiv., 187.

NATROLITE.

Crystals from Bombiana, near Bologne. Artini.—*Zeit. f. Kryst.*, abstract, xx., 172; natrolite of Monte Baldo, analysis, Luzzato.—*Ibid.*, 175.

OCTAHEDRITE.

Pyramidal black metallic crystals upon slate at Avon Slate Quarries, Buckingham Co., Va. George H. Williams, *Amer. Journ. Sci.*, xlii., 431, 1891.

ORPIMENT.

Deposition from hot spring waters of Yellowstone Park. W. H. Weed, *Amer. Journ. Sci.*, xlii., 403, November, 1892.

PARAMELACONITE, *Koenig*. *CuO*. Tetragonal.

Foote brought from the Copper Queen Mine, Bisbee, Arizona, two specimens which are now in the collection of C. S. Bement, of Philadelphia. All other specimens of this material are supposed to have been smelted.

The paramelaconite specimen shows a sort of monolithic crystal with three other smaller crystals, the pyramidal point and base are of a deep black color and adamantine lustre. They rest upon a mass of diminutive needle-like crystals (footeite) of a splendid indigo blue color, and a lustrous black or brownish ground mass of limonite and cuprite.

The paramelaconite is tetragonal, greatly resembling Brazilian anatase, $c = 1.6643$.

$H = 5$. Color on crystal surface violet black, on fracture raven black; fracture slightly conchoidal streak deep black. $G = 5.833$.

In O.F. the edge is rounded, in R.F. easily fused leaving button of copper. Soluble in strong HCl easily to a yellow solution.

Analysis showed:

| | |
|---|---|
| $CuO$, . . . . . | 100.68 |
| $Fe_2O_3$, . . . . . | 0.64 |
| | 101.32 |

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Considering excess as oxygen we find:

| | |
|---|---|
| $CuO$, | 87.66 |
| $Cu_2O$, | 11.70 |
| $Fe_2O_3$, | 0.64 |
| | 100.00 |

Since the tenorite of Vesuvius, the melaconite of Lostwithiel and the furnace product of Freiberg, are all, according to Kalkowsky, triclinic (or monoclinic), and the Lake Superior material apparently only pseudomorphic isometric after cuprite; Koenig proposes that the name melaconite shall represent the triclinic CuO, and the name paramelaconite, the new tetragonal form, and that the name tenorite be dropped.—*Zeit. f. Kryst.*, 1891, xix., 597.

PAINTERITE.

A name applied by Mr. Jefferis to a bright golden yellow vermiculite found on the farm of Mr. James Painter, Middletown, Delaware Co., Pa., but often applied to the brownish waxy matrix in which the mineral is imbedded.—*Amer. Journ. Sci.*, xlii., 247, 1891.

PENNINITE.

Crystallographic examination of kämmererite by Pirsson.—*Amer. Journ. Sci.*, xlii., 408, November, 1891.

PIEDMONTITE.

The manganese epidote, piedmontite, forms an essential component of a widely distributed rock in Japan, and is also an accessory component of a still more plentiful glaucophane schist. The piedmontite schist is characterized by its dark violet color and alternate layers of fine parallel piedmontite crystals and quartz grains. The accessory minerals are hydrous mica, garnet, rutile, felspar and hematite. The glaucophane schist shows some piedmontite, but its place is often taken by ordinary epidote.

The piedmontite is generally pure, in elongated crystals usually fissured or broken and lying nearly always with the orthopinacoid parallel to the plane of schistosity.

The rock is most typically developed in the Island of Sikoku, near the city of Tokusima, but is widely distributed also on the main Island Honsiu.—Prof. Kotô in *Quarterly Journ. Geolog. Soc.*, August, 1888, p. 474.

POLYDYMITE.

Material of Grüneau mine, near Kirchen, described by Laspeyres. with general discussion of composition of this and of material of Kohlenbach, near Eiserfeld, and Sudbury, Ont.—*Zeit. f. Kryst.*, 1891, xix., 417.

PYROPHANITE, *Hamberg*, $MnTiO_3$. *Hexagonal.*

Occurs at Harstig Mine, Sweden, in deep blood-red rhombohedral crystals, and is amorphous with hematite and menaccanite. H., 5; G., 4.537.—*Amer. Journ. Sci.*, xlii., 433.

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QUARTZ.

Study of by A. Bömer, *Neues Jahrb. f. Min.*, Beil, Bd. vii., 516–555, 1891; crystal structure of pyrogenetic quartz, O. Mugge.—*Neues Jahb. f. Min.*, 1892, i., 1–11.

REALGAR.

Deposition from hot spring waters of Yellowstone Park.—W. H. Weed, *Amer. Journ. Sci.*, xlii., 403, November, 1891.

RHODIZITE.

Optical properties of Ural rhodizite and its behavior when heated.—C. Klein, *Neues Jahrb. f. Min.*, 1891, i., 97.

RIEBECKITE in Britain.

In micro-granite at Island of Ailsa Craig, in Firth of Clyde.—Teall, *Mineralogical Magazine*, ix., 219, March, 1891.

In quartz porphyry, at Mynydd Mawr.—Harker, *Geol. Mag.*, v., 455, 1888, and Cole, *Mineralogical Mag.*, ix., 222–224.

In pebble from Isle of Man.—*Last cit.*

ROWLANDITE, *Hidden.*

A probable uni-silicate of yttrium found with the other Llano Co., Texas, minerals. Color pale and drab green; transparent in thin splinters; G., 4.515. Alteration products are waxy brick red in color.—*Amer. Journ. Sci.*, xlii., 430.

RUMPFITE. *Firtsch*, $H_{28}Mg_7Al_{16}Si_{10}O_{65}$. Hexagonal?

A fine, scaly, greenish-white mineral, with an easy basal cleavage; translucent on edges; white streak; H = 1.5; G = 2.675. Infusible before the blowpipe, but made somewhat brown. Yields water in closed tube. Insoluble in HCl and conc. $H_2SO_4$. Occurs in small, apparently hexagonal plates, irregularly massed and bent like helminth. Optically uniaxial. Analysis yielded $SiO_2$ 30.75, $Al_2O_3$ 41.66, FeO 1.61, CaO 0.39, MgO 12 09, $H_2O$ 13.12 = 100.12.

Found with talc in dolomite at St. Michael, Upper Styria.—*Neues Jahrb. f. Min.*, 1891, i., 31 Ref.

SCOLECITE.

M. Ferdinand Gonnard concludes that the mesotypes of Puy-de-Dôme, Auvergne, probably do not include scolecite, as he can find nothing corresponding to the analysis of Guillemin, published *Ann. des Mines*, xii., 390, 1826.—*Bull. Soc. Franc. Min.*, 1891, xiv., 173.

SIGTERITE.

The angles observed on the new feldspar, sigterite ($R_2Al_2Si_3O_{10}$), correspond to those of albite, and C. A. Tenne has proved the presence in the sigterite of an admixture of the well-known elæolite of Brevig. Tenne shows also that an admixture of, for example, $\frac{2}{3}$ elæolite and $\frac{1}{3}$ albite corresponds fairly well to the mean of five of Rammelsberg's sigterite analyses:—

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| | ⅔ Elæolite, ⅓ Albite. | Mean of 5 Sigterite. |
|---|---|---|
| $SiO_2$, | 52.87 | 49.93 |
| $Al_2O_3(Fe_2O_3)$, | 29.48 | 30.78 |
| $Na_2O$, | 14.27 | 13.36 |
| $K_2O$, | 3.08 | 4.24 |
| CaO, | 0.33 | 0.80 |
| | 100.03 | 99.11 |

—*Neues. Jahrb. f. Min.*, 1891, ii., 206.

SULPHUR.

Crystallized deposits in Yellowstone Park.—W. H. Weed, *Amer. Journ. Sci.*, xlii., 301, November, 1891.

SVABITE, *Sjögren*, $H_2O10CaO3As_2O_5$. Hexagonal.

From Harstig mine, Paisberg. In colorless prisms, with pyramids of first and second order.—Abstract in *Amer. Journ. Sci.*, xliii., 246.

TITANITE, of Zöptau.

Crystallization, F. Becke, *Tschermak's Min. Mith.*, xii., 169.

ULLMANITE.

Crystallized material from Landeskrone Mine, Wilnsdorf, near Siegen.—*Zeit. f. Kryst.*, 1891, xix., 424.

UMANGITE, *Klockmann*, $Cu_2Se.CuSe$. *or* $Cu_3Se_2$.

Found associated with the eucairite of Sierra de Umango, Provinces of La Rioja, Argentina.

Crystals unknown, forming compact, very finely granular masses. Cleavage not observed; fracture, fine granular, uneven to slightly conchoidal; brittle; H. = 3; G = 5.62; lustre, metallic; opaque. Color on fresh fracture, dark cherry-red to violet, very similar to freshly broken bornite, but noticeably darker; on surface dull and more of a violet blue; streak black. Alters to green, malachite-like products.

In closed and open tubes a sublimate of selenium, on coal melts easily and forms a gray mass, of probably $Cu_2Se$, which is somewhat malleable, and on further treatment with soda yields easily a button of copper.

Is found with eucairite, tiemannite and calcite in limestone.

Analyses yielded Cu 56,03, Ag 0.49, Se 41.44, $CO_2H_2O$, etc., by Dif. 2.04.—F. Klockmann, *Zeit. f. Kryst.*, xix., 269, 1891.

URANINITE.

New analyses by Hillebrand.—*Amer. Journ. Sci.*, xlii., 390, November, 1891.

URANOTHORITE.

According to Hidden, a partial examination of the Orangeite of Landbö, Norway, proves it to belong to the Uranothorite of Collier and

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the earthy brown (" thorite ") mineral with black pitch-like core from the same locality he believes to be impnre uranothorite.—*Amer. Journ. Sci.*, xli., 440, 1891.

VESUVIANITE.

Study of the idocrase occurring in the serpentine at Mussa Alathal Piedmont.—J. Strüver, *Neues Jahrb. f. Min.*, 1891, i., 25–39.

VIVIANITE, of Tamanj, Russia.

Analyzed by W. Tjelouchin, *Zeit. f. Kryst.*, xx., 183.

WOLFSBERGITE.

Crystallized material from Wolfsberg, Harz.—*Zeit. f. Kryst.*, xix., 428.

WOLLASTONITE.

Measurement of crystals from Vesuvius, with literature references. —P. Grosser in *Zeit. f. Kryst.*, 1891, xix., 604.

## MISCELLANEOUS CRYSTALLOGRAPHY, ETC.

CONSTRUCTING CRYSTAL MODELS BY PLAITING.

The faces lying in one zone are drawn on card-board and the lines partially cut through, and then the zones are plaited; for instance, the three zone strips of the cube: 1 passes over 2, 3 passes over 1, 2 passes over 3, and so on. The method gives rigidity and shows zone relations. —J. Graham, *Min. Mag.*, ix., 235, March, 1891.

H. A. Miers recommends for attaching crystals to goniometers a mixture of two parts, by weight, of beeswax fused with one of pitch.—*Mineralogical Magazine*, ix., 216. March, 1891.

REFERENCES MATHEMATICAL CRYSTALLOGRAPHY, ETC.

Methods. { *Zeit. f. Kryst.*, xix., 340–351, and xx., 84–90; E. Nickel, on Calculations, etc.
*Ibid.*, xix., 352–356, and xx., 143; v. Goldschmidt, on Graphic Methods of Measurement and Representation.
*Neues. Jahrb. f. Min.*, Beil, Bd. vii.; B. Hecht, on Calculation Intercepts of Triclinic Crystal from Angles made by Four Planes, no three of which are in same Zone.

Apparatus. { *Mineralog. Mag.*, ix., 214; Miers, on Student Goniometer.
*Neues. Jahrb. f. Min.*, 1891, ii., 224; Lehmann, Improvement in Crystal Microscope.
*Ibid.*, Beil, Bd. vii., 497–505; Czapski, on New Microscope for Crystallographic and Petrographic Investigation.

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A RAPID METHOD FOR DETERMINATION OF SULPHIDES, ARSENIDES, ANTIMONIDES AND DOUBLE COMPOUNDS OF THESE BODIES WITH METALS.

The mineral to be tested is finely powdered, a small crucible of platinum or porcelain is one-fourth filled with coarsely crushed ammonium nitrate crystals, and upon this about one-half grain of the powdered mineral is placed, and the crucible held in the flame of a Bunsen burner. Excess of ammonium nitrate does no harm. During fusion characteristic colors may be observed. The crucible is allowed to cool, the contents extracted with water, and the solution separated from the insoluble matter.

| | The fused mass. | The hot-water solution contained— | The insoluble residue contained— |
|---|---|---|---|
| Löllingite, $FeAs_2$ | Red hot. | $As_2O_3$, $As_2O_5$. | Fe. |
| Proustite, $Ag_3AsS_3$ | ..... | $Ag_2SO_4$. | As. |
| Pyrargyrite, $Ag_3SbS_3$ | ..... | $Ag_2SO_4$. | $Sb_2O_3$, $Sb_2O_5$ |
| Argentite, $Ag_2S$ | ..... | $Ag_2SO_4$*. | ..... |
| Pyrite, $FeS_2$ | ..... | $Fe_2(SO_4)_3$(br'wn) | $Fe_2O_3$) reddish brown). |
| Galenite, PbS | ..... | ..... | $PbSO_4$ (white). |
| Chalcocite, $Cu_2S$ | Blue hot, brown cold. | $CuSO_4$ (blue). | ..... |
| Bismuthinite, $Bi_2S_3$ | Brown cold. | $Bi_2(SO_4)_3$. | ..... |
| Millerite, NiS | ..... | Ni,Fe,Co,$SO_3$, (green). | $Fe_2O_3$ (brown). |
| Chalcopyrite, $CuFeS_2$ | Reddish brown. | $CuSO_4$ (blue). | $Fe_2O_3$ (brown). |
| Bournonite, $CuPbSbS_3$ | Yellowish green. | $CuSO_4$ (blue). | $PbSO_4Sb_2O_3$,$Sb_2O_5$ |
| Tetrahedite, $Cu_8Sb_2S_7$ | Green hot, brown cold. | Cu,Fe,(Zn)$SO_3$, (blue). | $Sb_2O_5$, ($Fe_2O_3$). |
| Smaltite, (CoFeNi)$As_2$ | Pink hot. | $As_2O_3$. | CoO,$Fe_2O_3$,NiO. |

* Addition of sulphur increases the amount of $Ag_2SO_4$ formed.

When As and Sb combine with metals in absence of sulphur, the method gives insoluble oxides of the metals; by adding sulphur, the metals are converted into soluble sulphates.

If to the melted mass containing oxides, in such a compound as smaltite, a lump of ammonium nitrate be added from time to time, and the mass kept simmering three or four minutes, nitrate of cobalt will be formed, which may be leached out, leaving NiO free from cobalt.

If sulphur is present with Co and Ni, fuse the mass in a silver crucible with 10 per cent. powdered carbon and four times its weight of caustic soda. On leaching, the oxides will be left, which may be separated as above.—C. A. Burghardt, in *Mineralogical Mag.*, ix., 227–234, March, 1891.

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METALLURGY, BY JOSEPH STRUTHERS.

ALUMINIUM —(*Journal of the Franklin Institute*), April, 1892.—Dr. A. E. Hunt, of Pittsburgh, discusses the manufacture and uses of aluminium considered from an engineering standpoint.

ANTIMONY. ENGLISH PROCESS FOR SMELTING.—(*Journal of the Society of Chemical Industry*, January 30, 1892).—Mr. Edward Rodger, after criticizing the various processes as described in the majority of text-books as inaccurate and obsolete, gives the following description of the English process:

The ore selected is stibnite, with a quartz gangue yielding about 52 per cent. of metallic antimony. It must be free from arsenic and lead as these two metals cannot be eliminated. The ore as it arrives in England is in bags, of various sized pieces, it is ground under edge runners and passed through a coarse screen about one-inch mesh. The greater bulk of material passed, however, consists of fine particles, a sample of which is analyzed to ascertain the quantity of iron necessary for complete reduction.

The processes of smelting consist in reducing the sulphide of antimony by means of metallic iron, the fusion taking place in crucibles which are heated in a very long reverberatory furnace.

The furnace consists of a bed 54 feet long including the fireplaces, and 7 feet 4 inches inside width, covered by a low arch which springs almost from the surface of the ground. The bed of the furnace being below the surface. This long gallery is heated by means of a fireplace at either end, the two fires drawing into a common flue in the middle of the furnace. The flue is arranged below the bed of the furnace and the ports are in the bed, this arrangement being to prevent the heat from being drawn to one side, as would be liable to happen were the flue to start directly from the side of the furnace. The sides and top are covered with one-inch cast-iron plates, while a two-inch square malleable iron bar runs on each side, the whole length of the furnace, under the upright binders which are tied over the top of the arch by tie-rods.

The floor of the furnace-room is covered with cast-iron plates extending out from the furnace walls about three feet; the remainder of the floor is paved with granite.

The fireplaces are below the ground level and have suitable fire-pits.

Along the top of the furnace are forty-two circular holes, twenty-one on each side. These holes are 14 inches in diameter through which the crucibles are raised and lowered—the workmen standing on the roof of the furnace while handling the crucibles. In addition to these "pot-holes" are two holes in the furnace roof at each end of the bed, 4 inches in diameter, and used for cleaning clinkers, etc., from the ends of the bed. Each pot-hole is provided with a circular fire-clay cover, clamped around with an iron ring, which serves to protect the covers, holding the pieces together when they split.

The crucibles are 20 inches high and 11 inches outside diameter at the mouth, and are constructed of fire-clay and plumbago. The clay used is either Stourbridge or Hexam, and the plumbago must be free from iron, whatever its source.

Below are analyses of the two clays referred to:

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| | Stourbridge. | Hexam. |
|---|---|---|
| $H_2O$, | 7.00 | 7.44 |
| $SiO_2$, | 69.00 | 59.05 |
| $Al_2O_3$, | 22 00 | 25.61 |
| FeO, | 1.50 | 2 20 |
| MgO, | 0.54 | 0 75 |
| CaO, | 0.49 | 0.88 |
| $K_2O$, | 0.41 | 1.97 |
| $Na_2O$, | 0.18 | 0.28 |
| $TiO_2$, | ..... | 1.53 |
| | 101.12 | 99.71 |

The crucibles weigh 42 lbs. dry and consist of 35¾ lbs. dry clay and 6¼ lbs. plumbago. They are made in the usual manner by hand, costing about 2s. 6d. and are dried first by steam and then by the waste heat from the antimony furnace after which they are heated to redness in a kiln before introducing into the furnace.

The kilns used for this purpose are simple, upright chambers, with a high door in front and a chimney at the top. Below is a fireplace over which is built a low arch, whose top is levelled by means of fire-clay covers and is pierced with a number of pigeon-holes, to provide for the passage of the flame to the upper chamber. The crucibles are placed on the floor, leaving the holes clear, and when the chamber is full the door is closed and luted; a gentle fire made, which is cautiously augmented until the crucibles are a cherry-red heat, at which temperature they are kept until required, when they are withdrawn as needed.

The use of the 48 holes in the furnace is as follows: The pair of crucibles nearest the fireplaces at each end of the furnace are used for "starring," or refining the crude metal, while the remaining holes are divided as is found suitable for first and second meltings of the crude metal.

The charge for each crucible consists of:

| | Pounds. |
|---|---|
| Ground ore, | 42 |
| Wrought iron scrap, | 16 |
| Common salt, | 4 |
| Skimmings, or impure slag, | 1 |

The amounts, of course, will vary. Those given are for a 52 per cent. ore.

The scrap-iron used must be wrought and not cast. Tinned scrap is preferable on account of the small trace of tin whitening the resulting antimony. Part of this scrap is beaten up into a round ball large enough to loosely fit the top of the crucible; the weight of this ball is about 13 pounds. The balance of the scrap is added in the form of turnings or borings and mixed together with the salt through the ore. This mixture is dropped into the crucible through an iron funnel, the lump of beaten scrap being thrown in last of all, so as to form a sort of lid. The furnace hole is then closed with its cover for about half an hour, when the crucible is again examined. In the meantime a fresh charge is weighed out ready for the crucible the moment it is empty. As the charge melts the ball on top falls down and is gradually absorbed, the iron reducing the antimony to the metallic state and being converted into sulphide.

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The salt assists the separation of the slag and tends to promote the fusion of the siliceous matters of the ore. The workman examines the crucible from time to time to ascertain whether the fusion is taking place properly and presses down the ball of scrap on the top with a bar of iron. The length of time required for fusion and decomposition varies with the position occupied by the crucible, those far from the fire requiring a longer time than those close to it, but, as a rule, about four meltings are made with each crucible per twelve hours, making allowance for charging and occasional changing of crucibles, etc., a little less than three hours may be taken as the average length of time for a melt. In this connection must be remembered that the richer the ore the shorter the time to melt it. Opposite to each crucible, except those used for final refining, is placed a conical cast-iron mould which stands close by the furnace side; it is large enough to hold the contents of the crucible, and is furnished with a cast-iron lid. The fusion being complete the crucible is withdrawn, balanced on the furnace wall, and the contents poured into the mould. The mould has a circular hole in the bottom three-quarters of an inch in diameter; its object is to facilitate removal of metal when solid by means of a hammer and punch. The first portions of the metal poured into the mould chills and prevents any escape of the fluid metal. After casting, the crucible is examined, scraped out if necessary, replaced and recharged at once. When the mass is removed from the mould, the reduced antimony which collects at the bottom, is knocked away from the slag, which slag, if the fusion is conducted carefully, should be clean enough to be rejected.

The metal obtained in this manner is called "singles." The following is the analysis:

| | |
|---|---|
| Antimony, | 91.63 |
| Iron, | 7.23 |
| Sulphur, | 0.82 |
| Insol. matter, | ..... |
| | 99.68 |

The large quantity of iron shown in the analysis is due to the excess of iron which is necessary to reduce the whole of the antimony in the ore, and the next operation consists in removing this excess of iron and is called "purifying." It is accomplished by melting the "singles" with a small quantity of pure sulphide of antimony which has been lignated from the ore for this purpose. The charge for the second fusion consists of:

| | Pounds. |
|---|---|
| "Singles," broken in small pieces, | 84 |
| Liquated sulphide of antimony, | 7 to 8 |
| Salt as flux, | 4 |

Kelp salt is sometimes used as flux and is found to be very suitable.

The reaction in this fusion is similar to that in the last operation, the excess of iron in the metal reducing the pure sulphide of antimony to the metallic state and being itself transformed into sulphide of iron. The fusion is narrowly watched, great care being taken that the metal and the sulphide of antimony are thoroughly mixed; when the fusion is complete the fused mass is carefully skimmed with a cast-iron ladle

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placed on a long shaft and poured into the moulds. This metal is known as "star bowls," each fusion yielding a lump of about eighty pounds. The skimmings from this operation go to the previous one, as mentioned. An analysis of this "star bowl" metal yielded :

| | |
|---|---|
| Antimony, | 99.53 |
| Iron, | 0.18 |
| Sulphur, | 0.16 |
| | 99.87 |

The surface of this metal is covered with tiny bright specks due to the presence of sulphur, and is called "floured" metal; in order to remove this sulphur and finally to purify this metal another melting is required. The custom of the trade is that antimony shall be sold in flat ingots, each ingot being "starred" or crystallized on the upper surface, and in order to obtain this crystallized appearance it is necessary to melt the metal with what is known as "antimony flux," a flux difficult to prepare but when once prepared easily kept in order.

The process of making this flux is a rule of thumb one, mixing about three parts of American potash to two parts of ground liquated antimony sulphide and melting in the furnace. When the mixture is complete and the fusion quiet it is tried on a small scale in order to see whether it yields a good "star" or not; if it does so the ingot of metal is broken and examined for sulphur, if the metal is free from sulphur the flux is considered satisfactory and may be put in use, but otherwise the flux is remelted and more of one ingredient or the other is added as experience dictates; the forming of a satisfactory flux is a matter of some difficulty and one in which experience is the only guide.

The process of refining and starring the star bowls is as follows: The cold lumps of metal from the moulds are carried from the furnace house to an adjacent room where they are thoroughly cleansed from the adhering skin of slag by chipping with sharp hammers, this part of the work being sometimes done by women who acquire great expertness in removing the slag. Great care must be taken to have every particle of slag removed, as the presence of the smallest amount completely ruins the appearance of the ingots rendering them dull and lustreless.

The slag chippings are returned to the second melting. The star bowls having been cleaned they are broken small and a charge weighed out for refining, the charge being 84 pounds with sufficient flux to surround the ingots completely, the amount of flux varying with shape and thickness of the ingots, for ordinary ingots about 8 pounds are used. The melting takes place in the crucibles next the fireplace where the fusion will be the most rapid. The charge of metal is thrown into the crucible and closely watched; as soon as the metal begins to melt the flux is added. When the fusion is complete the mixture is stirred around once with an iron rod and then poured. The ingot moulds are placed side by side, having between them a wedge-shaped frame called a "saddle," the edge of which points upward, and upon which the charge is poured dividing the stream one-half going into each mould. These moulds are left to cool undisturbed, and as they cool the flux which covers the surface cracks and when quite cold can easily be knocked off.

The flux is used over and over again, a piece of carbonate of potash

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being added each time it is used; in this way the amount of flux keeps increasing, besides the potash some antimony and sulphur is taken up at each fusion.

The ingots must be completely surrounded by flux, a thin layer being between the mould and the metal, and the entire surface of the ingot covered to the depth of about a quarter of an inch. Under these circumstances the metal should always give a good star and preserve a good color. The traces of flux which adhere are removed by washing in warm water with the assistance of a little sharp sand. A great deal of volatization takes place from the melted metal in the pots, the fumes produced are condensed in the furnace flues, which are built in a winding manner, passing back and forth under the floor of the crucible drying stores, the heat of the fumes serving to dry the crucibles and the cooling effect of the crucibles serving to condense the volatile material in the fumes. The total amount of fume produced varies greatly; the richer the ore the less fume there is in proportion to the antimony produced, although the absolute amount of fume is greater than when a poor ore is worked. About 10 per cent. of the total antimony contents of the ore is volatilized, a greater part of which is condensed in properly constructed flues. The fume is a whitish body, heavy and rather crystalline, not unlike white arsenic in appearance, but more of a grayish color due to presence of soot, it contains about 70 per cent. of antimony. Its treatment is as follows: A test experiment is made to ascertain the amount of carbon, as coke or anthracite, necessary to reduce all the antimony present. This having been found it is mixed with the fume under edge-runners and a few pounds of the mixture added to each charge of the ore and iron in the fusion for singles. The gases given off from the smelting of the fume sometimes cause the contents of the crucibles to boil and overflow, but beyond the mechanical difficulties there is no great trouble in treating it. The ingots, known in the trade as "French metal," after being wrapped in straw are packed in kegs holding about six hundredweight net, the size of these kegs is about that of an ordinary butter firkin.

The value of any sample of antimony is judged not by analysis but by its appearance, and a good sample should exhibit the following characteristics: The star should be bold and defined, standing well up on the metal, the edges of the ridges sharp and straight. The metal itself should be lustrous and white, not dull and lead looking. Lastly, and most important, on breaking the ingot the crystals should be large and their surfaces free from specks, these specks, as mentioned before, indicating the presence of sulphur.

A discussion of this paper by the Society brought forth the point of the great expense of crucibles both in cost of manufacture and the amount of lost heat in the furnace, as the area covered by the crucible is comparatively very small. The question was raised as to the use of some other form of furnace, such as a water jacketed blast furnace. Mr. Rodger stated he believes such a furnace was in use, but the object aimed at being the production of much fume from poor ores, this being condensed, was afterwards reduced with carbon. He also mentions that a reverberatory furnace had been tried, but was unsuccessful.

BEARING METAL ALLOYS.—(*The Journal of the Franklin Institute,*

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February, 1892, pp. 81–93, and March, 1892, pp. 161–172.)—C. B. Dudley, Ph.D., states the requirements of a good bearing metal, giving analyses of more than twenty different alloys used for this purpose, and description of the comparative tests made to determine the value of the different alloys. Also the experiments made from which the different metals were calculated to produce the standard bearing now in use on the Pennsylvania Railroad.

FUEL. MOVABLE COKE OVENS.—(*American Manufacturer*, for March 19, 1892,) describes and illustrates the movable coke oven patented by Hugh Kennedy and in use at the Isabella Coke Works, Coketon, Pa. The special features of the coke oven is its construction, being of sheet-iron, cylindrical, lined with bricks and mounted on wheels which admits of removal from its foundation. The action of the oven is as follows:

When ready to discharge, a small travelling car is run back of the oven and by means of a small engine the oven is pushed off its bed, carrying the coke with it, which drops piece by piece into the pit in front of the foundation, where it can be thoroughly watered and handled. The oven is drawn back on its foundation as hot as when started and recharged with coal, which starts to burn the moment it touches the bottom.

The advantages claimed are: The saving of heat as the oven is not cooled down during removal; the lengthening of life of brick work as the temperature is constant, and the avoiding the use of scrapers and bars in removal. There is a device for handling and screening the coke which increases the value of this system by doing away with a great deal of labor required in the present style of ovens; the arrangement is to have for each oven two walls extending beyond the main foundation, carrying the rails upon which the oven moves; between these walls and directly under the oven when run out, is a 30° chute extending from the oven foundation to the outer edge of the wing walls. The upper end of the chute is formed by a screen 3½ feet wide and running the full length of the oven. As the coke drops from the oven it passes over the screen, the fine coke and dust passing through and being deposited in a car beneath, the coarse coke collecting at the lower end of inclined chute. Four illustrations accompany the article, showing the action of this oven.

COKE. THE SEMET-SOLVAY COKE OVEN WITH RECOVERY OF BI-PRODUCTS.—(*American Manufacturer and Iron World*, February 19, 1892.)—Ch. Demanet, C.E., describes the improved system now in use by the "Bois-du-Luc" Company at the Havre Colliery, giving illustrations of plan of works and sections of ovens. A discussion of the working and economy of these ovens is also given.

BLAST-FURNACE PRACTICE—GRAPHIC METHOD FOR CALCULATING BLAST-FURNACE CHARGES OR "BURDENS" (*Iron and Steel Institute*, 1891.)—The calculation of the respective amounts of the components of a furnace charge or "burden" is, although very simple, a somewhat tedious affair, and a method for facilitating the computations has been devised by H. C. Jenkins, using a slide rule.

The rule consists of two equal scales at right angles, one of which (*a*)

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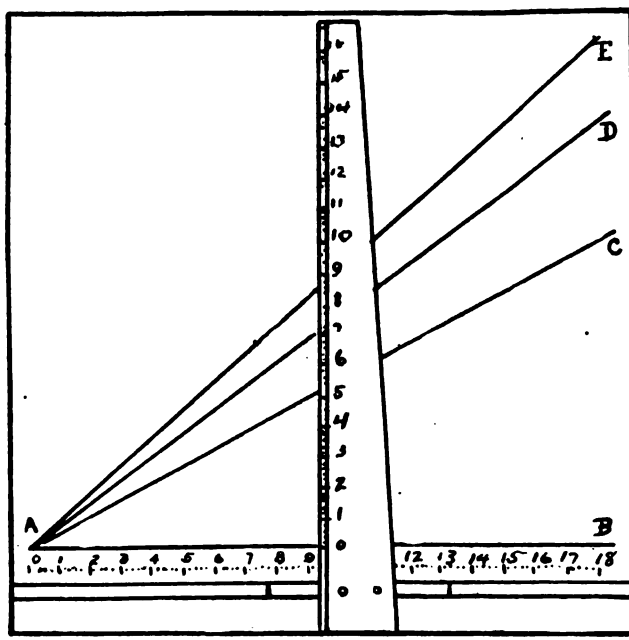
is fixed to a small board, whilst the other (*b*) is fixed at right angles to *a* upon a block (*c*), which is capable of sliding motion in a groove parallel to *a*.

The point *A*, given by the intersection of the zeros of the scales, is marked upon the board, and from it a line *AB* parallel to the groove is drawn. With *A* as a centre, lines *AC*, *AD*, *AE* are also drawn, making, with *AB*, angles whose tangents are equal to the ratios between the weight of the silica to weight of base in the respective silicates which it is desirable to produce in order to form the typical fusible slags ordinarily met with in blast-furnace practice.

The lines *AC*, *AD*, *AE* are marked with the names of the bases for




which they have been calculated. Thus *AC* makes an angle of 28° 10′ with *AB*—this angle having a tangent whose value is 0.5357, which is the ratio of the atomic weight of silica to twice the atomic weight of lime, and corresponds to calcium silicate; this line, therefore, is marked "Lime."

Similarly the line *AD* makes an angle of 36° 52′ with *AB*, the value of whose tangent is is 0.75, or the ratio of the atomic weight of $SiO_2$ to the atomic weight of 2 MgO; hence it is marked "Magnesia." Also the line *AE* is at an angle of 41° 25′, and this having a tangent corresponding to the ratio of the atomic weight of $3SiO_2$ to that of $2Al_2O_3$ makes the line correspond to the value of the component parts of silica and of alumina in aluminium silicate, and so it is marked "Alumina." With such a scale it is a very simple matter to at once read off either the excess of silica in any ore, or else the amount required to properly flux off the earthy bases present.

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As an example, let us take an ore containing

| | Silica required. |
|---|---|
| FeO 50, . . . . . | ..... |
| MgO 3, . . . . . | 2.25 |
| CaO 5, . . . . . | 2.68 |
| $Al_2O_3$ 3, . . . . . | 2.65 |
| $SiO_2$ 3, . . . . . | ..... |
| $CO_2$ 36, . . . . . | ..... |

Then setting the movable scale *b* against 3 on the fixed scale *a*, and looking along *b* until the line marked "Magnesia" cuts it, we find the value 2.25 as being the amount of silica required to satisfy the magnesia.

In like manner we find the amount (2.68) of silica required for the lime, and the amount (2.65) for the alumina respectively; adding all these together we find a total of 7.58 parts of silica required for every hundred of the ore. But as there are already three parts present, every hundred parts of the ore require $7.58 - 3 = 4.58$ parts of silica to flux it.

Due allowance is also made for the ash of the coke, and any small quantity of sulphur occurring in the mixture.

In the treatment of several kinds of ores to be smelted together they should be mixed and divided into three classes: One having *less* and and another *more* iron than is required in the final charge, and one should be *acid* and another *basic* after the correction for the ash of the coke is make, or one of these three may be a limestone or a siliceous flux; it need not necessarily contain iron. Then let it be required to have *n* parts of iron per hundred of the charge, and let $a_1\ a_2\ a_3$ be the percentages of iron in the ores, and $b_1\ b_2\ b_3$ percentages of deficiency (or excess) of silica in the same, and x, y, z the number of parts required of the component ores per hundred of the charge.

| FeO | $SiO_2$ |
|---|---|
| x | $(a_1 + b_1)$ |
| y | $(a_2 + b_2)$ |
| x | $(a_3 \pm b_3)$ |

then

$$(1)\quad x + y + z = 100$$

$$(2)\quad \frac{xa_1 + ya_2 + za_3}{100} = n$$

$$(3)\quad xb_1 - yb_2 \pm zb_3 = 0.$$

by solving these simple equations we have at once the number of parts of each component required to satisfy the conditions of the charge.

If it is desired to produce a more acid or a more basic slag, it only requires that the scale *b* be replaced by one having a length of one-half (for bi-silicate slag), or twice (for bi-basic slag) that of the normal scale.

COPPER. ELECTROLYTIC EXTRACTION.—(*The Engineering and Mining Journal*, March 19, 1892,) gives a description of the Siemen's electrolytic process for the extraction of copper from its ores as carried on at

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the works of Siemens & Halske, at Martini Kenifelde-Berlin. This process has been in continuous operation since June, 1890, on various kinds of copper ores.

The electrolytic extraction of copper from its ores has hitherto been employed by the use of impure copper or copper matte as anodes from which the copper was dissolved and deposited galvanically at the cathode. Only a part of the current is utilized, however, for dissolving the copper, the solution soon becoming poor and requiring replacement by a new solution the formation of which from the ores is attended with trouble and expense. Moreover, the uses of copper matte for the anodes required a previous smelting of the roasted ore, and the plates when once cast interfering with the process by falling to pieces before entirely dissolving. Soluble anodes are, however, necessary in the ordinary electrolytic process, because the use of insoluble anodes leads to strong polarization, which greatly reduces the efficiency of the current. In the Siemens method this difficulty is overcome by adding to the decomposing copper-carrying solution another solution, which takes up the oxygen set free at the insoluble anode and lessens the polarization. For such a deoxidixing solution ferrous sulphate is used which is changed by the oxygen set free at the anode into ferric sulphate, a lixiviant for the copper in the ore is thus obtained, as the ferric sulphate dissolves metallic copper as well as the sulphides of copper. Instead of the iron sulphates, the chlorides, ferrous and ferric, were formerly used with similar results, but abandoned on account of practical difficulties. Dr. Höpfner's method differs from the Siemens' by the use of cuprous and cupric chlorides instead of iron salts and a different construction of apparatus. The electrolyte used in the Siemens method consists of a solution of ferrous and cupric sulphates, with the addition of some free sulphuric acid to increase its conductivity. This liquid is continually added to the cathode chamber, where a portion of the copper is deposited by the electric current, after which the liquid passes down into the anode chamber and is finally drawn off at the bottom of the latter.

During this passage downward the ferrous sulphate is changed into basic ferric sulphate, then by the action of the free sulphuric acid coming from the decomposition of the cupric sulphate, which by its greater specific gravity sinks down to the carbon rods or plates, which compose the anode. The liquor drawn off has thus become poor in copper and consists of a solution of neutral ferric sulphate. This solution has the property of converting cuprous and cupric sulphides as well as metallic copper into cupric sulphate. The ferric sulphate is thereby reconverted into ferrous sulphate, while the oxygen set free oxidizes the copper.* The oxidation and solution of the copper can be completely carried out with many finely pulverized sulphide ores, even in an unroasted condition by the use of a moderately heated solution. With other ores, however, a moderate roasting of the pulp by which the copper compounds are con-

* Dr. W. Borchers, in his *Elcctro-Metallurgie* (1891), gives the following reactions as taking place during the process:

$xH_2SO_4 + 2CuSO_4 + 4FeSO_4 = 2Cu + 2\,Fe_2(SO_4)_3 + xH_2SO_4$.

$xH_2SO_4 + Cu_2S + 2\,Fe_2(SO_4)_3 = 2CuSO_4 + 4\,FeSO_4 + S + xH_2SO_4$.

$CuO + H_2SO_4 = CuSO_4 + H_2O$.

$3\,CuO + Fe_2(SO_4)_3 = 3\,CuSO_4 + Fe_2O_3$.

$CuO + 2\,FeSO_4 + H_2O = CuSO_4 + (Fe_2O_3 + SO_3) + H_2$.

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verted essentially into cuprous sulphide must precede the solution of the copper.

The lixiviation of the pulverized ore by means of the de-copperized and de-oxidized liquor is performed in troughs the pulp being kept in suspension by means of stirrers. The liquor coming from the electric cells is continually fed at the head of the trough, mixed with the necessary amount of pulp, and leaves the trough with the de-copperized pulp at the other end, the solution is hastened by heat supplied by steam pipes in the bottom of the trough. The pulp is separated from the solution either by settling or filter pump. The solution, now rich in copper and deoxidized, is fed anew to the electric apparatus. Thus the process is continuous between the leaching of the ores and the electrolysis of the solution, the lixiviant being produced electrically in the decomposition cells and the electrolyte regenerated chemically by the solution of the copper in the ores.

The time required in this method is about ten hours, and the amount of copper remaining in the residues is from 0.1 to 0.5 per cent., whether the ore is rich or poor. The chief requisite is mechanical power. A detailed description with illustrations is given of the arrangement of the plant and statement of cost of plant for producing 1000 kilos of fine copper from 4 to 4½ per cent. copper ore and from 35 per cent. copper matte.

CONVERTER FOR COPPER MATTE. *Colliery Engineer* for December, 1891, gives the following account of the patent issued July 11, 1891, to Pierre Mantes, of Lyons, France:

This converter is designed for producing copper from matte of any composition. In construction and operation it resembles the converter employed in making Bessemer steel.

The cylinder, *A*, is lined with refractory material and has end openings, *F* and *G*, through which the flame from any convenient heating furnace is run for the purpose of properly heating it before receiving a charge of matte.

These openings are covered when at work. The cylinder is provided with a vent or nozzle, *H*, and a blast box, *C*, having a number of tuyeres, *E*, which extend though the lining as shown. Blast is supplied through a jointed pipe, $C^1$ $C^2$. The cylinder is supported on rollers, *J*, upon a car, as shown. The apparatus can be propelled to any desired place by the handles, *T*. The cylinder is turned over to receive a charge or to bring the tuyeres beneath the metal by means of the crank, *N*. The charge is introduced through the nozzle, *H*, when in the position shown in Fig. 1, the blast is turned on and the cylinder is rotated to position shown in Fig. 2. The reaction commences immediately. The oxygen of the air combines with the sulphur and forms sulphurous acid, and with all the other bodies it forms oxides which are carried away by the gaseous current. A greater part of the iron which passes to the state of oxide remains in the bath and would soon injure the lining of the converter and quickly render it useless. To prevent this, powdered silica contained in a reservoir, *U*, is fed into the blast pipes and is brought into contact with the oxide of iron and forms silicate of iron, which melts and floats on the bath of melted matte. The volume of matte becomes less by the liberation of the sulphur and other bodies,



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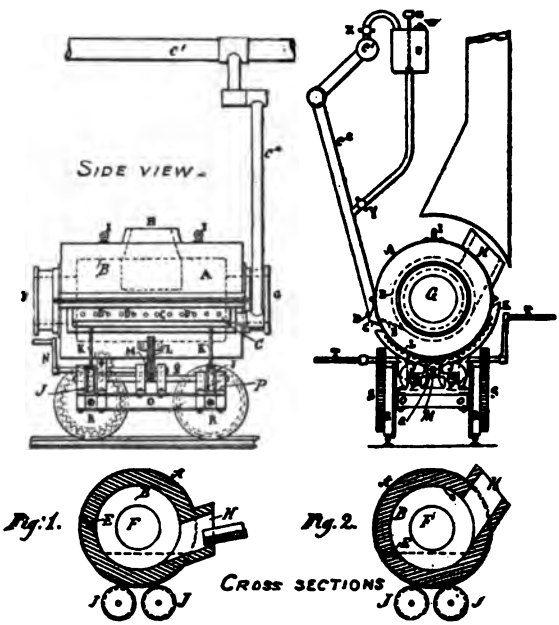
consequently the converter is turned slowly in order that the air blast may still penetrate the matte to the proper depth. The matte is thus concentrated and appproximates metallic copper by the loss of the other elements—iron and sulphur—as well as the combustion and volatilization of the metalloids and metals more easily oxidized. After a time there remains in the converter only sub-sulphide of copper and this is shown clearly by the color of the flame. The sulphur continues to burn and the copper is liberated and descends by gravity below the remaining sub-sulphide. The cylinder is then turned backward slowly so as to keep the tuyeres near the bottom of the layer of sub-sulphide until crude




copper alone remains. At the middle of the operation, when it is recognized by the color of the flame that all the iron has been burned, the converter is tipped to the position, Fig. 1, and the slag which floats, if sufficiently fluid, is run out, the air which strikes the surface at the rear of the bath being usually sufficient to force it out. If the slag is not fluid it is raked out by the usual means. The apparatus is afterward turned back to reduce, as aforesaid, the sub-sulphide of copper by still further blowing. By this process poor and impure mattes can be treated at will for obtaining either a white matte, absolutely free from iron and other bodies, or crude copper, or even refined copper in condition for rolling, and this is done in less than an hour after taking the matte from the blast furnace and without consumption of fuel.

LEAD—THE BASIC BESSEMER PROCESS APPLIED TO THE METALLURGY OF LEAD—The *Engineering and Mining Journal* for April 16, 1892, translated from *Revue Universelle de Mines de la Metallurgie*, for

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January 18, 1892.—Dr. Roesing, formerly Director of Friedrichshütte Works, Upper Silesia, has applied the basic Bessemer converter to the treatment of base-bullion. The lead is oxidized to litharge, which is then reduced by carbon or galena. A part of the lead may be desilverized by zinc and refined in the converter.

The following processes constitute the new system:

*a*. Treatment in the converter (1) of base-bullion for pure litharge and enriched lead; (2) enriched lead for impure litharge and lead-silver; (3) desilverized lead for refined lead.

*b*. Reduction of pure litharge by carbon for merchantable lead.

*c*. Treatment of galena with molten litharge for base-bullion.

Laboratory experiments and heat calculations favoring a trial on a large scale, a charge was made of 6000 kilos in a Thomas converter with successful results; the time of blowing was 15 minutes, with blast-pressure of 1¼ atmospheres. The lead had been previously heated a little above its melting-point. The litharge formed had a temperature higher than 1200°, and was very fluid; it crystallized on cooling without the formation of amorphous litharge; the silver contents being 0.0036 per cent., capable of being further diminished in regular working.

In treating poor impure zinciferous lead, the refined lead obtained was of excellent quality, and of the following composition:

| | Per cent. |
|---|---|
| Lead (by difference), | 99.9934 |
| Antimony, | 0.0007 |
| Arsenic, | 0.0005 |
| Copper | 0.0013 |
| Iron, | 0.0022 |
| Zinc, | 0.0015 |
| Silver, | 0.0004 |

In consequence of the great increase of temperature in the converter during the blowing, new charges may be worked immediately without reheating the vessel, so that there is no delay in the process. In regular operation it would be possible to utilize this heat for melting the lead.

The lining of the converter is but slightly affected; the opinion of the engineer of the Friedrichshütte steel-works being that that the basic lining of the converter will last better in the treatment of lead than in the manufacture of steel.

The impurities of the lead (zinc, arsenic, and antimony) are removed in a more rational manner than in the common process, since the blast acts uniformly throughout the mass, and not merely upon the surface of the bath; the latter is to-day purified the first, then uselessly oxidized, while the impurities contained in the lower strata of the metal are a long time withheld from the action of oxygen, resulting in an oxidation which is superfluous and injurious to the lead. In the new process it is necessary to take into account the reduction in the expense of treatment, and the loss in the working of intermediary products; as for the loss in blowing, there is produced naturally in that operation very thick lead smoke, but as it is of very short duration, the amount is small and can be easily recovered because

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it is not mixed with combustible products. In this process there is a saving, in comparison with cupellation, according to the calculation made at Friedrichshütte, of $4.50 per 1000 kilogrammes of base-bullion. As for enrichment of lead, it is recommended not to carry it too far at once, but rather to interrupt the blowing at intervals, and unite the lead of several charges, which can be submitted to a new operation for enrichment.

In experiments with base-bullion containing 0.0425 per cent. of silver, lead assaying 0.673 per cent. of silver has been obtained as a maximum, and condensed fumes of 75 per cent. lead and 0.0086 per cent. silver.

The litharge obtained is very liquid and can be reduced in a simple manner, by pouring it on a bed of incandescent carbon in a special furnace, by which it is immediately reduced. The same furnace may be employed for the treatment of the galena; the latter is comminuted to fine grains and heated to the point where roasting commences. If the liquid litharge is spread on this galena it is rapidly decomposed, with the evolution of sulphuric acid gas, which is mixed neither with an excess of air nor with combustion products, and consequently can be recovered easily. The rapidity of the decomposition of the litharge by carbon, or by the galena, permits of a large production in a small apparatus, and the consumption of fuel amounts only to that required in the preliminary heating; the amount of labor necessary, and the loss in metal, are both very small.

OPEN-HEARTH STEEL FURNACE.—*The American Manufacturer and Iron World*, for March 11, 1892, gives the drawings of an open-hearth steel furnace of the Siemens' type, which has the remarkable record of over a thousand heats without repairs to the crown. This furnace is at the works of the Apollo Iron and Steel Company, Apollo, Penn. This unusual longevity is the result of definite specified causes which admit of duplication. The beneficial modifications to the original type of Siemens furnace are the arrangement of gas ports so as to prevent the flame from impinging directly upon the walls and crown of the furnace and a straight roof in direction of its length. These points of construction, the use of best quality silica bricks and the intelligence and carefulness of the workingmen have given this excellent record.

The company has also another furnace of the same type from which fifteen hundred heats are expected before rebuilding.

TIN.—*The American Manufacturer* has issued a supplement on tin and tin plate, their history, production and statistics, by Joseph D. Weeks, 33 pages.

STEEL CASTING—THE FORMATION OF BLOW-HOLES (*Engineering*, January 1, 1892).—Two theories have been proposed to explain the formation of blow-holes in steel castings, neither of which has so far succeeded in satisfying all parties. When it was discovered, at Terrenoire, that an addition of silicon to the molten metal tended toward the production of sound castings the theory was advanced that the blow-holes were due to carbonic oxide, which compound is broken up by silicon at high temperatures. But the discovery that the gas contained in these blow-holes was principally hydrogen and nitrogen, with but a small proportion of

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carbonic oxide, did much to unsettle this theory though its advocates by no means abandoned the field.

M. le Berrier, engineer-in-chief of mines and professor at the Conservatoire des Arts ét Métiers, proposes a theory which accounts for the effects of silicon in producing sound castings, and also for the presence of hydrogen in these blow-holes, as follows: He regards the bath of cast steel as a supersaturated solution of hydrogen and nitrogen, if it is solidified quietly nothing disturbs the molecular equilibrium, but if by a secondary reaction bubbles of some other gas are produced in the body of the molten fluid, this disengagement, feeble as it may be, destroys the equilibrium just as in a supersaturated solution of a gas in a liquid, the passing in of a few bubbles of some other gas may cause the disengagement of the first. This carbonic oxide, though forming only a small part of the total gas set free, is quite capable of liberating the other gases with which the blow-holes are mainly filled.

CHROME STEEL, ITS MANUFACTURE AND USES WITH COMPLETE CHEMICAL ANALYSES.—(*Stevens' Indicator*, January, 1892, pp. 49–65.) This interesting article is an abstract of the graduating thesis of Messrs. B. Franklin Hart, Jr., and Julius Calisch describing the method of manufacture as carried on at the Brooklyn Chrome Steel Works, the different grades of the products with uses to which each grade is put, the properties of chrome steel in general and analyses of raw material and finished products, giving also the method of analysis pursued.

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W. Walker (*Journal Amer. Chem. Soc.*, xii., 256.) As a result of many experiments the following table has been arranged to show the order of strength of the various explosives (nitro-glycerine being taken as the standard and rated at 100.)

| | | |
|---|---|---|
| 1. | Explosive gelatine made from nitro-glycerine after the Vouges process, | 106 17 |
| 2. | Hellhoffite, | 106.17 |
| 3. | Nitro-glycerine (made Nov. 19, 1889), | 100.00 |
| 4 | Nobel's smokeless powder, | 92.38 |
| 5. | Nitro-glycerine(made Jan. 29, 1890, and tested on same day), | 92.38 |
| 6. | Explosive gelatine (made from nitro-glycerine No. 5), | 88.95 |
| 7. | Gun cotton (U. S. N. Torpedo Station, 1889), | 83.15 |
| 8. | Gun cotton (Stowmarket, 1885), | 83.12 |
| 9. | Nitro-glycerine (made according to the French process and tested the same day). | 81 85 |
| 10. | Gun cotton (made in Artillery School Laboratory), | 81.31 |
| 11. | Dynamite No. 1, | 81.31 |
| 12. | Dynamite de Trouzl, | 79.31 |
| 13. | Emmonsite, | 77.86 |
| 14. | Amide powder, | 69.87 |
| 15. | Oxonite (picric acid fused before being added), | 69.51 |
| 16. | Tonite, | 68.24 |
| 17. | Bellite, | 65.70 |
| 18. | Oxonite (picric acid not fused), | 64.24 |
| 19. | Rack-a-rock, | 61.71 |
| 20. | Atlas powder, | 60.43 |
| 21. | Ammonia dynamite, | 60.25 |
| 22. | Volney's powder No. 1, | 58.44 |
| 23. | " " No. 2, | 53.18 |
| 24. | Melinite, | 50 82 |
| 25. | Silver fulminate, | 50.27 |
| 26. | Mercury fulminate, | 49.91 |
| 27. | Mortar powder, Dupont, | 28.13 |

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ANALYTICAL CHEMISTRY, BY E. WALLER, PH. D.

*Utilizing the Electric Light Current in Laboratory Work.* Stillwell and Austen (*Jour. Anal. and App. Chem.*, vi. 129.) Thermopiles and galvanic batteries are inferior to the current from dynamos when that is available. The current is almost invariably so strong that it requires to be reduced. Resistance coils are liable to be attacked by the laboratory fumes. "Blackened lamps" no longer useful for illumination are the cheapest and best form of resistance. The older patterns of lamps have a lower resistance than those of recent manufacture. The resistance changes with the temperature, *e.g.* a lamp of 127 ohms when cold, has been found to give only 36.6 ohms resistance at white heat. The resistance of two lamps of equal resistance while hot, when arranged in series (110 volt current) is greater than twice the resistance of one. The current may be measured most conveniently by the gas afforded per minute. Roughly 10 c.c. gas = one ampere. (More exactly 1 c.c. = 0.0958 ampere.) Very small currents may be obtained by passing a side current around a lamp. By this means large and small currents may be simultaneously obtained.

The cost of the current may be placed at about one cent per hour for a current of 0.75 ampere.

*Asbestos in Filtration.* Barba (*Jour. Anal. and App. Chem.*, v. 596 and vi. 35.) If finely divided asbestos is stirred in with a precipitate and the whole is then filtered through a layer of asbestos the operation is often much facilitated. This mode of management is especially useful in filtration of $MnO_2$ in the chlorate method (Ford's) or of carbon in the analysis of manufactured irons.

*Action of $BaO_2$.* Kwasnik (*Berichte*, xxv., 67.) With ferrocyanide, all of the oxygen is evolved and ferrocyanide is formed. With ferric salts but half the oxygen is evolved; ferrous salts act in a similar manner. Ferric salt first forms and the evolution of O ensues. Salts of the alkaline earths have no effect whatever. Mg salts act slowly; Zn and Cd salts more rapidly; Co and Ni salts very promptly. Mn, Cr and Al salts act in a similar manner to the ferric salts. Cu salts act promptly. The above liberate only half of the O of the $BaO_2$. Hg, Ag and Au salts evolve the whole of the O with separation of the metal. $PtCl_4$ is not reduced but an escape of O occurs, $PtCl_4, BaCl_2.8H_2O$ being formed. If, however, $PtCl_4$, 2HCl is mixed with $AgNO_3$ in proportions to form $PtCl_4$ 2 AgCl, and $BaO_2$ is then added, the Pt is reduced to metal. With all insoluble Ag salts the action, though slower than with the solution, was the same.

*Examination of Minerals.* Burghardt (*Chem. News.*, lxv., 44, 53) gives a plan for the ready testing of minerals, sulphides, arsenides, etc. In place of the test with Ofl on Ch he uses $NH_4NO_3$ in a crucible as more satisfactory. The separation of nickel and cobalt was found to be effected by fusing with $NH_4NO_3$, and keeping the mass simmering for three or four minutes, adding a little nitrate from time to time if necessary, then on cooling the mass was boiled with water which dissolved cobalt nitrate and left behind NiO. If the mineral is a sulphide,

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mix with 10 per cent. of powdered carbon and fuse with four times its weight of caustic soda; cool, extract with water and test the residual oxides with $NH_4NO_3$ as above.

*Spectroscopic Determination of Potassium.* Gooch and Hart (*Am. Jour. Sci.*, xlii., Dec.) Coils of platinum wire, such as recommended by Truchot (*Comptes Rend.* lxviii., 1022), were found to be suitable. The form used was 2 mm. in diameter, by 1 cm. in length, made of No. 28 wire (0.32 mm. diameter) and wound in about thirty turns. Their capacity was one-fiftieth of a grm. of water. The method employed was dilution of the solution tested until a coil full of the liquid showed with a 0.23 mm. slit, a line of the same brightness as that given by a corresponding amount of a standard solutiom. Sodium when present in proportion of 100 parts to 1 of potassium, practically extinguished the potassium lines in qualitative testing, when dilution to extinction of the potassium line was tried. When comparison was made with the potassium line obtained from a standard solution, NaCl was found to produce a brightening of the K line so that the estimations of K under these conditions were above the truth. By adding NaCl to the standard solution, this error was rectified.

*Separation of Calcium and Strontium.* Fresenius and Ruppert (*Fres. Zts. Anal. Chem.*, xxx., 672.) Strontium can be precipitated from a solution by addition of $K_2CrO_4$ and one-third its bulk of alcohol. Free acetic acid prevents the formation of insoluble $SiCrO_4$, ammonia salts favor it. Calcium is not precipitated under these conditions. The method recommended is to separate Sr and Ca (Ba being absent) by precipitation as carbonates, redissolve in HCl and evaporate until neutral, dilute, warm to 70°, add $K_2CrO_4$ and alcohol, until the solution contains about 30 per cent. by volume and filter off $SiCrO_4$. In the test analyses Sr ran a little low, and Ca a little high.

*Analysis of Commercial Aluminum.* Hunt, Clapp and Handy (*Jour. Anal. and App. Chem.*, vi., 24). *Solvents* concent. HCl (Sp. Gr. 1.2) dissolves the metal with such a vigorous escape of gas that there is danger of loss by foaming over. A dilution of about 1 : 2 is better for general work.

Nitric or sulphuric acids, whether dilute or concentrated, are very slow in their action.

Aqua regia, even when containing one sixth as much HCl as $HNO_3$, and a volume of water equal to that of the mixed acids, dissolves the metal completely when hot.

KOH, 40 per cent. solution (15 c.c. per gm. of metal), is efficient, but more expensive than acids.

*Silicon.* On dissolving in acids, some graphitoidal Si always remains, which oxidizes slowly by heating over the burner, or by treatment with KOH, but readily by fusion with alkaline nitrate. The residue after dissolving in acid and treatment with $HF + H_2SO_4$ leaves a mixture of Si and $SiO_2$, the latter from partial oxidation of the heated Si. Some of the graphitoidal Si is also volatilized in the treatment. A method which seems promising consists in filtering the residue from hot HCl through a platinum cone, washing with HCl, drying at 80° C., then

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washing with HF + $H_2SO_4$, followed by hot water, drying at 80° and weighing again. The weight of the residue is approximately that of the graphitoidal Si.

For *Total Silicon* dissolve 0.9334 gm. of drillings in 15 c.c. $HNO_3$ (Gr. 1.2) with 2 c.c. conc. HCl. After action has nearly ceased, add 2 c.c. more of HCl. With very pure grades heat the mixture for some little time thereafter. Then add 20 c.c. conc. $H_2SO_4$, and evaporate to fumes; after cooling treat with 75 c.c. water and 10 c.c. HCl, boil five minutes, filter, wash with water, then with hot (30 per cent.) HCl, and again with water. Burn off the paper, fuse with about 3 gms. $Na_2CO_3$, dissolve in HCl, add 15 c.c. conc. $H_2SO_4$ and evaporate to fumes, and then repeat the treatment described for the former evaporation with $H_2SO_4$. The weight of the $SiO_2$ thus obtained divided by 0.02 gives per cent. Si.

*Iron and Copper.* Dissolve 1 gm. in 40 c.c. diluted HCl (1 : 2). Boil, dilute to 250 c.c. and saturate the solution with $H_2S$. Filter off Si, CuS, etc. From this residue the Cu may be extracted and determined, *e.g.*, it may be ignited, extracted with $HNO_3$ and the solution evaporated and ignited, so as to obtain CuO, or the electrolytic battery separation may be used. In the solution, after boiling down to 50 c.c., the iron may be determined by titration with $K_2Cr_2O_7$ in the usual manner.

*Aluminum* is frequently determined by difference (deducting percentages of Si, Fe and Cu). For the direct determination dissolve 1 gm. in 25 c.c. of HCl (1 : 2) and evaporate to dryness. Take up with HCl, filter, dilute and pass $H_2S$, filter, boil out $H_2S$, make up to 250 c.c., take 50 c.c., nearly neutralize with ammonia, add 5 c.c. ammonia sulphate solution, and 10 c.c. $Na_2S_2O_3$ solution (both saturated solutions). Boil out $SO_2$ and filter. Redissolve in HCl and reprecipitate by ammonia and addition of a little phosphate, boil, filter, wash, dry, ignite in porcelain and weigh as $AlPO_4$.

*Chromium* may be added to impart hardness.

Dissolve 2 gms. in 50 c.c. of a 10 per cent. solution of KOH, boil and filter. The residue contains the Cr. Burn off the paper, treat with 1 c.c. $H_2SO_4$ and 5 c.c. HF. Evaporate to fumes of $SO_3$, fuse with 4 gms. $KHSO_4$ for twenty minutes at a low temperature, then over a blast lamp so as to expel nearly all free $SO_3$. Cool, add a little $Na_2CO_3$, then $KNO_3$ and fuse. Cool, dissolve in water, filter, add $NH_4Cl$ and warm to cause separation of silica and alumina, filter, and in the filtrate, reduce the chromate, and precipitate in the usual manner, purifying the precipitate by at least one re-solution and reprecipitation.

*Titanium* imparts toughness and resistance.

To determine it, dissolve 2 gms. in KOH solution as for Cr. After dissolving boil ten minutes, dilute to about 125 c.c., boil up and filter, washing ten times with boiling water. Burn off the filter in a porcelain crucible, crush and mix in a platinum crucible with 6 gms. $KHSO_4$. Heat to fusion with a small flame. At intervals of five minutes remove from the heat temporarily and give the contents of the crucible a rotating motion. At the end of fifteen minutes raise the temperature until the lower one-fourth of the crucible is red hot, shaking occasionally as before. In ten minutes more apply the full heat of

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the burner for five minutes, then cool, add 2 gms. more $KHSO_4$, and gradually bring to homogeneous fusion, avoiding the expulsion of much $SO_3$. Pour the melt out upon a clean, cold surface, and when cool digest the cake as well as the crucible with 150 c.c. of water kept at 40° C. until solution is effected. Filter and test the residue with HF and $H_2SO_4$. It should consist entirely of silica. Neutralize the solution with ammonia, render slightly acid with $H_2SO_4$, dilute to 250 c.c., saturate with $SO_2$, heat up slowly, and boil for 45 minutes, adding a little $SO_2$ water from time to time. Filter off $TiO_2$.

In the filtrate oxidize up the Fe precipitate by ammonia, redissolve in HCl and titrate with $K_2Cr_2O_7$.

In case Ti is present the Si determination is managed as already described, except that a little more HCl (20 c.c.) is used in re-dissolving after evaporation with $H_2SO_4$.

*Dichromate Titration of Iron.* Namias (*Gazz. Chim. Ital.*, 1891, 473, through *Jour. Anal. and App. Chem.*, vi., 36). The author prefers to add an excess of dichromate solution and then to titrate back with $SnCl_2$, after adding a drop or two of iodine and the same amount of starch solution. He claims that the $SnCl_2$ reacts first with the dichromate, then with the starch iodide, and finally with the ferric salt.

*Analysis of Ferrochrome.* Warren (*Chem. News*, lxv. 186). Dissolve in strong $H_2SO_4$ and heat to dissolve the alloy with evolution of $SO_2$. Continue heating until copious fumes of $SO_3$ are evolved. Then add a few drops of HCl, dilute and heat until only a carbonaceous residue remains undissolved. Filter, and in one portion determine Fe by titration with standard bichromate, in the other portion precipitate chromium and ferric hydrates together by ammonia, ignite to oxides and weigh. Deduct from this weight that of the $Fe_2O_3$ present and calculate the remainder as $Cr_2O_3$.

*Iron and Alumina in Phosphates.* Glaser method. Gibbins (*Chem. News*, lxv., 51) reports as to the application of this process to Florida phosphates (*vide* QUARTERLY, xi., 273, etc.). He finds that any interference due to the presence of MgO may be prevented by avoiding the addition of *excess* of ammonia to an aliquot portion of the alcoholic solution. If the ammonia is added drop by drop from a burette until, on stirring and testing with litmus paper, the solution is found to be just neutral, and then the alcohol, expelled by evaporation on the steam-bath, but *not to dryness*, and the solution then boiled, with the addition of a few drops of ammonia, settled and filtered, no MgO is found in the precipitate. The Florida phosphates frequently contain some Mn, which will appear in the precipitate. To remove this, it is recommended to wash partially, redissolve in dilute $HNO_3$, add a little $(NH_4)_2HPO_4$, and then ammonia until neutral, when a precipitate free from Mn is obtained. (Such is the statement, but the rationale of this operation is not clear. *Abs.*)

*Separation of Iron, Aluminum and Chromium.* Marchal and Wiernik (*Zts. Angew Chem.*, 1891, 511). The sulphuric acid solution is neutralized with $Na_2CO_3$ until a slight permanent precipitate forms, which

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is just redissolved by addition of a few drops of HCl or $H_2SO_4$. Freshly precipitated $MnO_2$ suspended in water is then added, stirred in well, and the solution boiled. (The $MnO_2$ is obtained for the purpose by precipitating a neutral solution of $MnSO_4$ by permanganate, and washing thoroughly). The ferric oxide is precipitated, while the chromium is converted to chromate. The solution should be tested with ferrocyanide to determine when all iron has been precipitated. In the filtrate the alumina is precipitated by ammonia, and in the filtrate from that the chromium is reduced and precipitated with the usual precautions.

*Separation of Iron, Manganese and Calcium.* Riggs (*Jour. Anal. and App. Chem.*, vi., 94). Experiments are recorded in which repeated basic acetate separations of the iron (ammonium acetate) and repeated Br separations of Mn (in ammoniacal solution) followed by $(NH_4)_2C_2O_4$ precipitations were used. The conclusions are that in separating the iron, an excess of the acetate is undesirable. Two precipitations are sufficient. The Br precipitation of Mn should be repeated if over 0.02 gm. of either MnO or CaO are present. The presence of acetates, as well as the addition of Br to the hot ammoniacal solution is best, when separating $MnO_2$.

*Cobalt in Manganese Ores.* Moore (*Chem. News*, lxv., 75). Two methods are given. *First method*: Mix 2 gms. of ore with 4 to 5 gms. $KHSO_4$ in a platinum dish and fuse 15 to 20 minutes at the highest temperature afforded by a Bunsen burner. Then add little by little, solid ammonium carbonate continuing the heat, until $SO_3$ fumes come off but feebly, keeping the dish covered. Pour the melt on a clean, cold surface, and allow it to cool. Dissolve in about 400 c.c. of boiling water, boil for about 20 minutes, settle and wash by decantation. The insoluble residue will contain no Ni or Co. Heat the filtrate, add 30 c.c. acetic acid, pass in $H_2S$ and when all iron is apparently reduced, add 50 c.c. of strong solution of $NH_4C_2H_3O_2$ to the boiling solution. Ni and Co will separate as sulphides. Let settle, filter and wash thoroughly, convert to sulphates and deposit by electrolysis. Separate the two by any good method, the precipitation of Co as ammonio-phosphate being preferable.

*Second Method.* This depends on the absorption of oxygen by ammoniacal solutions of cobalt. In presence of citrate, Mn hardly absorbs any oxygen. The reaction is: $2CoO + O = Co_2O_3$, or at standard temperature and pressure, every c.c. of O absorbed indicates 0.0105 gm. Co.

To 2 gms. of the ore, add HCl, and evaporate to dryness. To the residue add 3 gms. $H_3C_6H_5O_7$ in 3 or 4 c.c. ammonia; render *distinctly* acid by addition of HCl if it is not already acid. Heat until all soluble material is dissolved, then cool. Introduce the solution into a Bunte gas burette (a graduated tube, with bulb and stop-cock at each end). Make up the volume with water to the zero mark, and then introduce 4 or 5 c.c. of strongest liquor ammonia saturated with $NH_4Cl$. Connect the lower bulb with a reservoir of water, and agitate the apparatus until no further absorption takes place. Note the contraction in volume of the air, and after correcting for pressure and temperature, calculate the Co present.

*Separation of Zinc and Manganese.* Jaunasch and Niederhofheim

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(*Berichte*, xxiv., 3945.) The mixed sulphates in 50 c.c. of solution, are mixed with 10 c.c. of a 10 per cent. KCy solution and 10 c.c. of a 25 per cent. KOH solution in a platinum dish. After stirring until the precipitate is nearly redissolved, the Mn is precipitated by addition of 50 to 60 c.c. of $H_2O_2$ solution, and heating (covered) on the water bath for about 15 minutes. The filtrate is acidified with HCl and evaporated to dryness to separate silica. The solution from the $SiO_2$ is precipitated in the usual manner with $Na_2CO_3$. The Mn precipitate had best be redissolved in dilute $HNO_3$ by the aid of (not over 0.3 gm.) oxalic acid, and reprecipitated in ammonia solution by $H_2O_2$.

*Oxidation of Mineral Arsenides by the Electric Current.* Frankel (*Journal Franklin Inst., Nov.*, 1891.) The conditions produced were: fusion of 25 to 40 gms. of KOH in a nickel crucible forming the positive pole—addition of the powdered mineral—passage of a current of one ampere for 20 to 45 minutes. The current was finally reversed for 3 to 5 minutes. Arsenides containing but one atom of As in the molecule such as niccolite arsenopyrite, etc., decomposed readily, those containing $As_2$ as smaltite, etc., required the longer time, and the larger proportion of KOH. The method of determining arsenic as sulphide was found to be extremely unsatisfactory.

*Analysis of Antimony Ores.* Carnot (*Bull. Soc. Chim.*, vii. and viii., 219.) For stibnite or other sulphides, place 2 to 5 gms. in a flask, add 50 to 60 c.c. conc. HCl and heat to just short of boiling. When action has apparently ceased, decant the solution through a filter, add a fresh lot of acid, and heat again, treat a third time in the same manner adding one or two drops of $HNO_3$. In the clear solution precipitate Sb by inserting a strip of metallic tin, and heating to 80–90°. One gm. of Sb is ordinarily precipitated under these conditions in about and hour and a half. Wash by decantation with dilute HCl, finally rinse off with alcohol dry and weigh on a weighed filter.

With ore containing antimony oxides convert to sulphide and then treat as above. The conversion to sulphide is effected by spreading a weighed amount of the ore over the bottom of a flask, into which is delivered dry $H_2S$ (passed through $CaCl_2$) the ore being maintained at 300°C by a low flame (Rose burner) beneath it. The end of the tube should be close to the surface of the powdered ore. An hour's treatment in this manner is usually sufficient. Lead is the only element likely to interfere with this process. It was found best to weigh the metal in the manner described, and then to treat the weighed precipitate with yellow sodium sulphide, heating to 50 or 60°, which dissolved out Sb and leaves PbS, which is filtered off, dried and weighed. Theoretically 86 per cent. of this PbS is Pb, but experiment showed that under these circumstances it is more accurate to deduct $\frac{9}{10}$ of the weight of this precipitate from that of the mixed metals. Arsenic if present, only exists in unweighable traces in the precipitate.

*Lead, Silver and Zinc in Ores Containing Galena and Blende.* Aubin (*Bull. Soc. Chim.*, vii., 134.) Treat 10 gms. of ore in an Erlenmeyer flask of 1 litre capacity with 50 c.c. fuming nitric acid—evaporate to dryness, redissolve with 20 c.c. $HNO_3$ (Gr. 1.33) and heat; dilute to 400

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c.c. and after agitation filter on a counterbalance filter; after weighing, triturate the insoluble $PbSO_4$ and gangue with 30 to 40 c.c. of a 20 per cent. solution of alkaline sodium tartrate. Filter again through counterbalanced filters and wash, dry and weigh, thus obtaining the weight of $PbSO_4$ by difference. The solution containing Ag and Zn is made up to 500 c.c. In 50 c.c. the Zn is determined by separating Fe with ammonia, and Zn in the filtrate by $H_2S$, dissolving and precipitating as carbonate. In the remaining 400 c.c. the Ag is separated by addition of NaCl. (The method as described is open to criticism—*Abs.*)

*Tin, Gold and Cadmium in Alloys.* French (*Ch. News*, lxv., 133.) One to two gms. were dissolved in as little HCl as possible, and the Au filtered off. The filtrate was nearly neutralized by KOH solution, 4 to 5 c.c. of $H_2O_2$ (10 volume) added, and the solution boiled, after dilution to half a liter. The tin was thus readily and completely precipitated. In the filtrate Cd was precipitated by $K_2CO_3$.

*Determination of Molybdenum.* Péchard (*Comptes Rend.*, cxiv., 173.) By passing HCl gas over an alkaline molybdate in a tube heated to 440° the Mo is completely sublimed as $MoO_3 2HCl$. The white needles are easily soluble in water, and by evaporation of this solution to complete dryness at 100° leave pure $MoO_3$. A slight bluish sublimate insoluble in water usually also appears in the tube together with the white needles. This is easily rinsed from the tube by dilute $HNO_3$. It consists of some lower Mo oxide.

*Volumetric for Tellurium.* Brauner (abs. in *Fres. Zts. Anal. Chem.*, xxx., 707.) Four methods are mentioned: 1. Titrating the HCl solution of Te $O_2$ by $SnCl_2$. Te separates, the solution remaining turbid until an excess of $SnCl_2$ has been added, when it clears. The excess of $SnCl_2$ is determined by titrating back with standard iodine.

2. Oxidation of tellurous to telluric acid by $K_2Cr_2O_7$.

3. Oxidation of the element Te by I in alkaline solution.

Both of these last were found to be unsatisfactory.

4. Oxidation of $TeO_2$ to $TeO_3$ by $K_2Mn_2O_8$ in alkaline solution free from chlorides. This last was found to be the most accurate and expeditious method thus far tried. If one has the HCl solution of $TeO_2$ it is best to evaporate with $H_2SO_4$, then dilute, supersaturate with NaOH and titrate with permanganate. (*Vide* QUARTERLY xii., 167 and 264.)

*Phosphorus Determination by Acidimetric Titration of the Molybdate Precipitate.* Manly (*Jour. Anal. and App. Chem.*, vi., 82). The standard alkali should contain 6.6 gms. NaOH per liter. 1 c.c. should equal 0.0002 gm. P.

The standard acid should correspond with the alkali, c.c. for c.c. It is made by diluting 10 c.c. $HNO_3$ (Gr. 1.42) to 1 liter and then diluting as titration shall determine.

The indicator used is phenol-phthalein. A stock of purified "yellow precipitate" should be kept on hand for standardizing. This is prepared by washing the precipitate free from reagents with three per cent. nitric acid and re-dissolving in ammonia (of 15 per cent). Filter and boil off nearly all of the ammonia, then add $HNO_3$ (Gr. 1.2). Then

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evaporate to dryness and finally heat over the lamp until fumes of $HNO_3$ and $NH_4NO_3$ cease to come off. There is no danger of overheating during the fuming. Cool and keep in a stoppered bottle.

Standardize by weighing out 0.2 gm. of yellow precipitate, run in 20 c.c. of alkali, then add the indicator (size of a pin's head), and stir until dissolved; titrate back with the standard acid. The strength is correct if 3.7 c.c. of acid is required (20 — 3.7 = 16.3, or 0.163 per cent. P). It will be more convenient if the solutions are brought to this strength.

For steels dissolve 2 gms. in 30 c.c. $HNO_3$ (Gr. 1.2) in an Erlenmeyer flask. Boil out nitrous fumes, oxidize with 4 or 5 c.c. permanganate (10 gms. per liter) until a cloud, permanent on boiling, is formed. Add HCl drop by drop and boil until the solution is perfectly clear. Cool somewhat, neutralize with diluted ammonia (1 : 1) until the ferric hydrate dissolves only slowly. Avoid more than 3 per cent. excess of acid. Then warm to nearly boiling and add 50 c.c. of the molybdate solution. Shake for some seconds, stand on a sand-bath for five minutes and filter. Wash with 3 per cent. $HNO_3$, containing 3 per cent. $KNO_3$, till free from Fe and molybdate. Dissolve in (15 per cent.) ammonia into a porcelain dish. Boil off excess of ammonia, add 2 c.c. $HNO_3$ (Gr. 1.2), evaporate to dryness, heat to expulsion of fumes, as already described, and treat subsequently as when standardizing.

Pig-irons are treated in essentially the same manner, the amount to be taken varying from 0.5 to 2 gms., according to grade. $HNO_3$ of 1.135 gravity is preferably used, and the graphite, etc., should be filtered off before precipitating.

For ores, dissolve 2 to 4 gms. in HCl, evaporate to dryness, take up with HCl, dilute, filter, evaporate. Expel HCl by evaporation with $HNO_3$, dilute and treat as in previous cases. The time required for determination is approximately 40 minutes.

*Determination of Bromine or Iodine.* Nihoul (*Zts. Angew. Chem.*, 1891, 441.) The halogen is precipitated as the silver salt. After drying and weighing the silver compound is placed in a tube, converted to chloride by passing over it Cl or HCl gas, and again weighed.

*Estimation of Nitrous Acid.* Green and Evershed (*Chem. News*, xxv., 100). Prof. Lunge finds that the diazotization method described by these gentlemen gives incorrect results. Their claim is that he did not apply it in the right manner. Their restatement of their method may be given as follows: Dissolve 93 gms. pure, dry aniline with 450 c.c. (of 30 per cent.) HCl in 1 liter. 25 c.c. of this solution is placed in a stoppered bottle surrounded by ice water, and is then titrated with the nitrite solution (with constant agitation) until a drop of the solution gives a blue color *at once* with $ZnI_2$ and starch. When a slight excess of nitrous acid is still indicated after standing for an hour, the end-point has been reached.

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# BOOK REVIEWS.

A MANUAL OF MINING. By M. C. Ihlseng, C.E., E.M., PH.D., Professor of Engineering, Colorado State School of Mines. New York: John Wiley & Sons. Pp. 428. Price $4.00.

Except in the special field of coal mining, American technical literature has long lacked a treatise on mining which would serve as a thorough text-book for students, and as a reliable guide for practical miners and business men. American mining practice is, in many respects, in the front rank of industrial progress, but no American treatise on mining has appeared which could in any sense rank with such modern European books as Haton's *Exploitation des Mines* and Köhler's *Bergbaukunde.*

The appearance of Prof. Ihlseng's work is, therefore, a matter of interest. The author states in his preface that "the work is designed as an elementary treatise for the use of those desiring a reference book," and as such we must regard it.

The book is divided into two parts, as follows: Part I., *Mining Engineering*, which contains sixteen chapters on Geognosy; Preparatory and Exploratory Work; Methods of Mining; Hoisting Machinery; Electricity and Water Power; Hoisting Operations; Hoisting Conveyances; Underground Traffic; Surface Transportation; Pumping; Ventilation; Methods of Ventilation; Distribution of the Air; Regulation of the Air Current; Illumination; Hygienic Conditions.

Part II., *Practical Mining*, contains ten chapters on Shafts; Sinking in Running Ground; Timbering; Drifts, Tunnels, and Adits; Boring; Breaking Ground; Blasting; Drills and Drilling; The Compression of Air; Mine Examination.

The division into Parts is somewhat strained, as questions of both "Mining Engineering" and "Practical Mining" arise in almost all the subjects treated. But the headings of the chapters show that the author has taken a comprehensive survey of the field.

The book contains a large amount of practical information under the various headings, for the accumulation and arrangement of which much industry was required. It is well supplied with clear illustrations, many of them being reproductions from manufacturers' circulars, for which due credit is given.

While the arrangement under subjects is excellent, and most of the descriptions of methods and machines are clear and instructive, a review of the work demands that some defects be pointed out. This is the more necessary on account of the special importance at present of even an elementary work of such scope.

Turning, for instance, to Chapter III. of Part I., on Methods of Mining, we find nine systems enumerated: Overhand, Underhand, Traverse with Filling, Square Sets, Traverse with Caving, Long Wall, Pillar and Stall, Squares, and Panel. Although this list of methods is,

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on the whole, very good, yet the statements concerning the applicability of the methods will hardly find general acceptance. Thus—

*Overhand* stoping is said to be "for lodes of a thickness limited by the unsolidity of the ore" (p. 31); *Underhand*, "only for narrow veins, and may replace above (*i.e.*, Overhand) in those of rich ore, or where the entire lode is salable."

*Pillar and Stall* "requires a good roof" (p. 32), and the *Panel* method is said to be applicable to "thin coal beds, flatter than 25°; coal free; top rotten; mine gaseous." As to the *Long Wall* method, we are told (on p. 44) that "Long wall requires a bad roof; but if the roof be good it may be used, the filling replacing the material expected from the caving of the roof. This plan is sometimes used."

The above quotations will serve to show that the author's manner of defining the applicability of methods of mining is lacking in precision. The more detailed descriptions contain many good points, but the whole chapter is rather loosely written, and contains such inexact statements as "Coal beds less than 28 inches thick are unexploitable. The thinnest iron-ore bed mined is 43 inches" (p. 32). "A 28-foot gypsum bed sells but 29 per cent. of the area mined" (p. 43).

We note, also, some important omissions. In the chapter on Hoisting Machinery, the very important subject of counter-balancing receives only the most casual mention (on pp. 76–79); and under Pumping, there is no discussion of the evil of "forking air," with which all students and practical miners should be familiar.

Under Methods of Ventilation, the citation of Mr. R. Van A. Norris's conclusions concerning the working of centrifugal ventilators (p. 196) is badly summarized, and contains statements for which Mr. Norris should not be held responsible, such as "the influence of shape of blades shows that the back curvature is better," and "the efficiency is high if the peripheral velocity is large." A perusal of Mr. Norris's paper on Centrifugal Ventilators (presented at the meeting of the American Institute of Mining Engineers, October, 1891) will show that he has been only partially understood by the author.

Some uses of terms are hardly accurate. Underground Transportation ought not to be called Underground "Traffic," as in Chapter VIII., Part I.; and on page 2 there occurs the rather striking prophecy that the "abandoned *exploitations*" (of unlucky speculators) "will be pursued to profit, when the potential investment of to-day will have been resolved into future kinetic dividends." The use of the word "exploitations" in the evident sense of "explorations" is most unfortunate, even in an elementary treatise, and may, perhaps, be due to a typographical error. It is to be hoped, also, that the type-setter is responsible for the apparent superfluity of the statement, in the reference of five lines to Hydraulic Mining, on page 29, that "An ore of 20 per cent. gold per cubic yard pays." "oz." may have suggested "%."

Nevertheless, we have enlarged rather on the defects than on the merits of the work. In spite of such inaccuracies as have been pointed out, it contains much matter of practical value, especially in Part II., well arranged and illustrated. The book is convenient in form, is handsomely printed, and has an index.

WILLIAM ALLEN SMITH.

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LABORATORY MANUAL OF CHEMISTRY. By James E. Armstrong, Principal of Lake High School, Chicago, and James H. Norton, Principal of Lake View High School, Chicago, American Book Company. 8vo., pp. 144. 50 cents.

This book is intended more particularly for use in the laboratory in conjunction with Elliott & Storers's Manual of Elementary Chemistry, or some manual of similar scope. Being so intended, each alternate page is left blank (with but one or two exceptions) for notes. It contains some suggestions that may be of value to teachers. The points illustrated by the experiments and their arrangement, emphasize the fact that every teacher must lay out his own plan of instruction, adapting it to the capacity and needs of his students as well as other conditions. The experiments on latent heat are noticeable because usually omitted in many similar manuals. A similar remark may be made as to experiments which suggest to the student that the adhesion of liquid to his glassware may prove a source of error in the measurement of liquids.

In imparting to the student correct ideas as to acids and bases, the suggestions of this manual might be regarded by some teachers as throwing upon them too heavy a burden of explanation, for students often have a way of conceiving erroneous ideas from the perusal of a printed page, which give much trouble to correct by explanation. A few quotations may be given. P. 30: "Hydrates are a type of a class of substances called *bases*;" also "Call all the compounds you find that turn red litmus blue, *alkalies*." P. 32: "Call all elements that can neutralize an acid a base." (The italics are in the text, indicating apparently that a definition is given.) On page 30 also is given a table of "common base-forming elements," and "common acid-forming elements," the elements being given by symbols on either side of a dividing line. It is essentially the classification into metals and metalloids. No suggestion (by the arrangement of the symbols or otherwise) is given as to which elements form the more distinctively basic oxides. Sb appears among the base-formers, As among the acid-formers, and, for some unexplained reason, Cr only appears in both.

Experiments 30 to 39, inclusive, are on water. Experiments 40 to 53 are on air. The idea involved is good, indicating to the student the chemical relations of the commonest substances known to him, but it seems unfortunate to give prominence in that place to the impurities and accidental constituents of those substances. That, however, is a question of arrangement of topics which all through frequently seems odd and possibly confusing. E. g. after some experiments on flame, the blowpipe, etc., terminating with "Experiment 87. the Borax Bead," comes experiment 88, "Marsh Gas;" experiment 89, "Illuminating Gas;" experiment 90, "Alcoholic Fermentation;" experiment 91, "Vinegar;" experiment 92, "Fractional Distillation;" experiment 93, "Test for Sugars;" experiments 94 to 99, "Digestive Ferments, their Effects, etc.;" experiment 100, "Sulphides;" experiment 101, "Chlorides," etc. From here to the end (experiment 164) the ordinary qualitative reactions and methods for qualitative testing are made the subject of study.

As has been said, many teachers may glean from this book useful suggestions, but, as a whole, it would be adapted only to special conditions of instruction. E. W.

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# BULLETIN OF ALUMNI AND COLLEGE NEWS.

## Prize Essay on the Transmission of Power by Electricity, with Special Reference to its Application to Mining.

An Alumnus of the School of Mines of Columbia College has offered a prize of one hundred dollars for the best essay on the above subject that may be presented by a graduate of the School. The essays must be sent to Prof. W. P. Trowbridge on or before November 1, 1892. President Seth Low will appoint a committee to examine the essays and award the prize. The successful essay will be published in the School of Mines Quarterly.

## Department of Mineralogy and Metallurgy.

The geologists of the third class have this year received instruction in mathematical crystallography and optical mineralogy, the work in crytallography including lectures and practical instruction in measuring angles, calculating constants, delineation of forms by Quenstedt and Miller projections and by the clinographic method of Dana. In optical mineralogy the subjects treated were: Optical characters of different species, instruments, cutting of sections, identification of species, absorption, pleochroism, color, refraction, etc. It is proposed to further extend this course next year by lectures upon the classification of mineral species; the relations of form and composition between species of the same group; the genesis of minerals as illustrated by associations, pseudomorphs, alterations and synthesis; the determination of minerals by micro-chemistry, spectrum analysis, etc.

The following gifts have been made to the department:

*Mineralogical Cabinet.*—2 large specimens of chalcotrichite, from Arizona; presented by Dr. R. Pearce, of Denver, Colorado.

2 cubic cuprites, 1 atacamite, 2 mountain leather coated with copper oxide, 1 cuprite and pyrites, 1 malachite pseudomorph, 2 calcites; presented by A. L. Walker, 1883.

Series of alabandite specimens by W. Stanton, 1882.

1 chrysocolla pseudomorph, from Globe, Arizona; presented by N. S. Berray.

3 large specimens of agatized wood from Arizona, 1 large amethyst group from Lake Superior, 1 large pyrophyllite from North Carolina; presented by A. L. Hoyt.

1 specimen of petrified wood, and 8 specimens of gold ore from Wales; presented by J. R. Gordon, class of 1871.

1 schapbachite, 1 stoltzite, 1 tyrolite, 1 torbernite, 1 alabandite, 1 essonite, 2 sulphurs, 1 inesite; R. Hoe.

*Metallurgical Cabinet.*—23 photographs, 18 x 20, in oak frames, of Virginia City and vicinity; presented by N. P. Lounsbury.



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Drawing of a chimney; Ansonia Brass and Copper Co.
Model of a chimney; Philadelphia Engineering Co.
Drawing of a roasting kiln; A. S. Dwight, class of 1885.
Drawing of a waterback furnace; Fraser & Chalmers.

DEPARTMENT OF ELECTRICAL ENGINEERING.

Professor F. B. Crocker is building a 5000 volts continuous current dynamo which he intends to use for high insulation tests. The insulation resistance of materials against a continuous high voltage strain is a subject of great scientific interest and practical importance, but owing to experimental difficulties it has not been as yet seriously investigated.

Dr. M. I. Pupin has just brought to a close a part of his investigations on electrical discharges in partial vacua. The results so far obtained seem to throw considerable light on the nature of the solar corona, solar prominences, solar faculæ and the aurora borealis. He intends to continue his investigations with a considerably improved method. So far he has employed the ordinary alternating current of about 125 periods per second. He proposes now to employ electrical oscillations of several hundred thousand periods per second, and is building for that purpose a large oil condenser capable of withstanding a tension of 20,000 volts. The oscillatory current will be transformed to very high voltage by means of an oscillatory current transformer. Dr. Pupin expects to perform some of these experiments before the New York Academy of Sciences at their first meeting next month, at which meeting he is to read a paper giving a brief account of the results so far obtained. Some of the results have already been published in the April number of the *American Journal of Science.*

The second year students are busily engaged in their investigations which form the subject of their graduating theses. Some of the men have already obtained quite interesting results, especially Mr. Parmly, who is investigating the relation between the armature reaction and the load in continuous current dynamos and motors.

One of the last year's theses was very favorably commented upon by the electrical press of this country, and a reprint of it appeared in the *London Electrical Review.* It is the thesis of Mr. A. S. Ives, "On the Determination of Magnetic Leakage by means of a Weston Voltmeter." (See *Electrical World,* N. Y., Jan. 2, 1892.) Mr. Ives is now employed by the Thomson-Houston Company at Lynn, Mass.

DEPARTMENT OF PHYSICS.

"New York is soon to rob Washington of one of the cleverest and most promising of the younger members of the Government Scientific Corps. Dr. William Hallock, of the Smithsonian Institution, has just notified Director Langley of his acceptance of a chair as Adjunct Professor of Physics at Columbia College under Professor Rood.

"Dr. Hallock was born at Milton-on-the-Hudson in 1857. He was graduated from Columbia College in 1879. He held the three-year fellowship in science, and on it went to Würzburg, Germany, for a course of post-graduate study. Before returning to this country in 1882 he received an appointment as physicist on the Geological Survey, which he retained till last November, resigning it to enter the Smithsonian

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Institution as Assistant in Charge of the Physical Observatory. It is this place which he gives up to take the vacant chair in Columbia.

"While connected with the Geological Survey he conducted the investigation of subterranean temperatures in the famous dry well at Wheeling—the second in depth in the world—where the drill went down to 4500 feet below the surface of the earth. His experiments were described in a paper read last year before the American Association for the Advancement of Science. He was also for three years at work in the Yellowstone Cañon investigating the phenomena of the hot springs and geysers there, and comparing results with those obtained by Professor Bunsen in Iceland. In collaboration with Mr. Carl Barus of the Geological Survey he worked for some time at New Haven studying methods of measurement of high temperatures. Among the other topics to which he has given his attention are the effects of pressure on powdered materials and thermal expansion of rocks.

"Dr. Hallock acted at Würzburg as laboratory assistant, and afterwards as private assistant to Professor Kohlrausch. His degree, *summa cum laude*, was taken in December, 1881. Although a very diligent worker in laboratory and observatory, and turning out, alone or in association with other scientists, a dozen or more printed treatises, he has found time to gain some experience in teaching and lecturing, first with the classes in chemistry and physics at the Columbian University, and later at the College of Pharmacy in this city. He will begin work in New York with the fall term."—*Evening Post*, March 23.

DEPARTMENT OF ASTRONOMY.

The following changes have been made in this department since the death of Professor William Guy Peck:

The department of MECHANICS AND ASTRONOMY has been abolished; also the PROFESSORSHIP OF HIGHER MATHEMATICS AND ASTRONOMY has been done away with. The mathematics formerly taught by Professor Peck is now under the charge of Professor Van Amringe; all the astronomy has been placed in the department of ASTRONOMY, which is the new name of the department of GEODESY AND PRACTICAL ASTRONOMY.

The titles of the officers in this department have been changed to conform to the new naming. The third year class in Geodesy has been placed under Mr. Jacoby's instruction for the present. The work in mechanics, both in the mines and art schools, has been for the present turned over to Professor Rees, who has, with the approval of President Low, placed Dr. M. I. Pupin in charge of the work in higher mechanics, and Mr. Pfister in charge of the work in mechanics for the Juniors and third year Architects.

The trustees at their last meeting took steps toward the creation of the office of Adjunct Professor in Mechanics. It is expected that this chair will be filled very soon.

For a couple of years, at least, the mechanics will be under the charge of the new Adjunct Professor, as an officer of the department of Astronomy.

Eventually the subject of Mechanics will be put into a separate department, and may include mathematical physics, higher mechanics and engineering mechanics.

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The force in Astronomy has been increased by the appointment of J. T. Monell, C. E., E. E., as Tutor in Astronomy.

PHOTOGRAPHS OF THE MOON.

*Work Done at Columbia College Observatory.*—Prof. John K. Rees, Professor of Geodesy and Astronomy, and Director of the Observatory at Columbia College, has just despatched a series of photographs of the moon to Prof. Dr. L. Weinek, of the Imperial Observatory at Prague. They are from negatives made by Dr. L. M. Rutherfurd between 1862 and 1870, and which now are in the possession of Columbia College. The photographs represent the moon in all its phases, and the positives which have just been sent were prepared by Mr. Monell, of the Columbia College Observatory.

Dr. Weinek is engaged in making a large map of the moon, nine feet in diameter, from his own observations and from the photographs which have been made at the Lick Observatory. The Rutherfurd photographs are to be used in making necessary comparisons. Prof. Rees has also sent quite a complete set of similar photographs to the Lick Observatory. Dr. Rutherfurd presented these negatives of the moon, together with some apparatus and many other photographs, to the College in November, 1890; and a complete list of the negatives of the moon, sun and stars has been published by Prof. Rees in the annals of the New York Academy of Sciences. With the negatives were given a great many volumes of measures of star plates made by Dr. Rutherfurd, and the reduction of these measures has been pushed forward with considerable enthusiasm by Dr. Harold Jacoby, of the Department of Astronomy. The results of the Pleiades reductions will soon be printed, while the reductions for the group about $\beta$ Cygni are also complete, and their publication may be expected soon.

Prof. Rees has in his study some photographs of the moon that have recently been made by students in the Observatory, and which compare very favorably with the work of observatories with much larger instruments and greater facilities. The work of the Columbia College Observatory is greatly hindered by the small space given to it in the present college buildings, as well as by a lack of sufficient funds. The removal of the college naturally raises the question of a new observatory.—*Evening Post*, April 13, 1892.

DEPARTMENT OF ARCHITECTURE.

THE Second Competition for the Columbia Fellowship in Architecture came to a close on Saturday evening, February 27th, when the final drawings for "a school of architecture to be erected in New York City" were handed in by the fifteen competitors. Four weeks later the jury, consisting of Messrs. R. M. Hunt, C. F. McKim and Thomas Hastings, Jr., of this city, announced the awards. The Fellowship was won by Mr. H. B. Mann, 1890, who will shortly start on his travels in compliance with the purposes of the Fellowship, which gives him $1300 "to be expended in foreign study and travel in accordance with plans to be approved by the President and the Professor of Architecture.

Mr. Stoughton, 1888, the winner of the first competition for this Fellowship is still in Paris, where he has been engaged in architectural

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study for the past two years, and the winners of both the McKim Fellowships of 1891 are also in Paris. Messrs. Muñoz, of 1889, and Welch, of 1890, are also in Paris, with several others from this department, including Messrs. Hewlett and Kohn of 1890, who won Honorable Mentions in last year's competition. Whether Mr. Mann will join this colony or not has not yet been announced.

The jury also awarded an Honorable Mention to Mr. W. L. Thorne, 1890, and "highly commended" the plans submitted by Messrs. Hornbostel, Raymond and Strout, all of 1891. It is understood that the weakest element in most of the designs was the exterior treatment, which only in the winning design clearly suggested the nature and purpose of the building. The problem was an unusually complicated one, and the number of drawings required greater than has been the cases in the previous competitions for the Columbia and McKim Fellowships. The burden was somewhat lightened, however, by allowing all but one of the final drawings to be made away from the college, and by permitting the competitors to employ assistance in certain ones among them. The number of competitors who completed the work was fourteen, a gain of 60 per cent. over the first competition in 1890.

Next year the McKim Fellowship will again be offered for competition.

An unusual amount of original design has been this year incorporated with the work in architectural history of the second, third and fourth classes. The subjects of the designs have been in each case related to the topics assigned for original investigation in the preceding week, thus making the historical study directly applicable to design, and giving directness and point to the investigation of historic monuments.

On the evening of March 24th, Professor Ware was knocked down by a wagon while crossing Third Avenue at 59th Street, and badly hurt, being confined to the hospital for a week, and to his room for several days after leaving the hospital. His escape from serious injury was very remarkable, and although he has not yet regained his former strength, he has been able to resume at least a part of his accustomed labors.

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## JULY, 1892.

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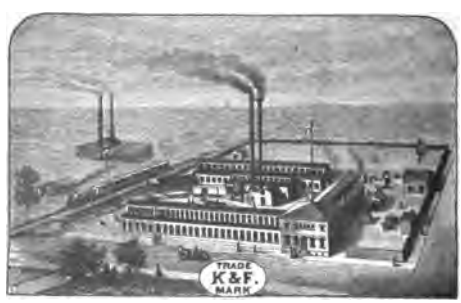


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# SCHOOL OF MINES QUARTERLY.

VOL. XIII. JULY, 1892. No. 4.

## ANCIENT METHODS OF DIVIDING AND RECORDING TIME IN JAPAN.

BY THOMAS EGLESTON, PH.D.

THE ancient methods of computing and of recording time in Japan, both for historical purposes and for the uses of daily convenience, were very peculiar. They are like everything else Japanese, which has not been influenced by the contact with foreign nations, interesting on account of their evident antiquity. All Japanese customs are, however, rapidly disappearing in the general adoption of European ideas, and but little of their ancient methods remain.

The Gregorian calendar went into force in the year 1873, but it was adopted in a modified form. To have accepted the whole of it would, in the Japanese mind, be equivalent to acknowledging that foreign ideas are supreme, which, although it is a fact in everything but religion, the people do not like to admit. There is now a reaction against foreign ideas, owing partly to the attitude of the foreign element in the treaty ports in the matter of treaty revision, and partly to the fact that the Greek Church in Tokio has been built in such a situation as to overlook the Emperor's palace, which every Japanese resents, the Emperor, as the head of the Shinto religion, having had from time immemorial by their customs and laws the right to always be above any possible



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inspection. The erection of a high dome on this church was forbidden by the government on account of the popular clamor created when the design was made public. To use the Christian era would be to admit the supremacy of foreign religious ideas in a country where the mystery which surrounds the very presence of the Emperor makes him the popular object of worship, and would be utterly repugnant to the ideas which the people have of his sacred character. Besides the arrangement of the calendar into periods more or less near to each other, the appointing of year names, as they are called, by which these periods are designated, has always been considered amongst the Eastern nations as one of the signs and sacred rights of an independent sovereignty. To admit that any other custom of any other nation or nations could impose by right, or even by usage, a practice which would do away altogether with year names, would, both in Japan and China, take away one of the most dearly cherished rights of the semi-sacred Emperor, who not only promulgates the name which he has arbitrarily chosen amongst his own people, but imposes it on his vassals. In China the year name corresponds with the commencement of the reign of an emperor, but in Japan it has not heretofore been so. The year names were imposed whenever it pleased his Majesty. It has been announced, however, that in the future these names will be made to coincide with the commencement of reigns only. With the arbitrary way in which it has heretofore been done, the student of history is often in the greatest perplexity, as it is almost impossible to ascertain the relation between our dates and theirs, and when the names have been changed, as they frequently have been, several times in the same reign, the problem becomes almost impossible of solution. Very few of the Japanese themselves know all the year names of their own country. The most prominent of them are used in ordinary conversation, such as *Engi*, A.D. 901 to 923, famous on account of the revision of the then legislation; *Genroku*, 1688 to 1704, the time of great cultivation of the arts; *Tenpo*, 1830 to 1844, the most brilliant time of the present century. But it is not known how many years intervened between the periods, and as they were short, it is very easy to mistake fable for history, an error which is very common amongst Eastern nations. At the time of the reform made in time in the year 1872, a Japanese era was introduced which was made to commence with the reign of *Jimmu-Tenno*, the mythical ancestor of the

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present Imperial Dynasty, the beginning of whose reign is supposed to have been 660 B.C. This makes it possible to make historical comparisons. The year 1892 of our era would then be 2552 of the Japanese. The present year name is *Meiji*, which was given in 1868.

The names for these eras are made up of the signs of the zodiac and what are called the ten celestial stems obtained by dividing each of the five elements, wood, fire, earth, metal and water, into two, called respectively *elder* and *younger* brother. In addition the years, days and hours were considered as belonging to and were named after the signs of the Zodiac. These were called *ju-ni-shi*. These signs of the zodiac are:

1. *Ne* The Rat.
2. *Ushi* The Bull.
3. *Tora* The Tiger.
4. *U* The Hare.
5. *Tatsu* The Dragon.
6. *Mi* The Serpent.
7. *Uma* The Horse.
8. *Hitsuji* The Goat.
9. *Saru* The Ape.
10. *Tori* The Cock.
11. *Inu* The Dog.
12. *I* The Boar.

The five celestial elements which make up the "ten celestial stems," called *jik-kan*, are:

| | | |
|---|---|---|
| 1. | *Ki no E*, . . . . . | Wood— Elder brother. |
| 2. | *Ki no To*, . . . . . | Wood— Younger brother. |
| 3. | *Hi no E*, . . . . . | Fire— Elder brother. |
| 4. | *Hi no To*, . . . . . | Fire— Younger brother. |
| 5. | *Tsuchi no E*, . . . . . | Earth— Elder brother. |
| 6. | *Tsuchi no To*, . . . . . | Earth— Younger brother. |
| 7. | *Ka no E*, . . . . . | Metal— Elder brother. |
| 8. | *Ka no To*, . . . . . | Metal— Younger brother. |
| 9. | *Mizu no E*, . . . . . | Water— Elder brother. |
| 10. | *Mizu no To*, . . . . . | Water— Younger brother. |

When the signs of the zodiac and the celestial stems are put together, the *jik-kan* always being put first, they make a cycle of sixty years. The first year of this cycle is *Ki no E Ne*, Wood, elder brother rat. The tenth is *Mizo no Tori*, Water, younger brother cock, and then the cycle begins again. As there are only ten of these *jik-kan* they follow again in their order. The twelfth month would then be made up of No. 2 of the *jik-kan* and No. 12 of the *ju-ni-shi*, and so on, the cycle being so repeated indefinitely. This makes it very difficult to a European to follow the order of things, as the signs of the zodiac are so interwoven with days, months and years.

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The following is a list of the year names since 1800:

| | | | |
|---|---|---|---|
| *Kyowa*, | 1801–1804. | *Ansei*, | 1854–1860. |
| *Bunkwa*, | 1804–1818. | *Man-en*, | 1860–1861. |
| *Bunsei*, | 1818–1830. | *Bunkyu*, | 1861–1864. |
| *Tempo*, | 1830–1844. | *Genji*, | 1864–1865. |
| *Kokwa*, | 1844–1848. | *Keio*. | 1865–1868. |
| *Kaei*, | 1848–1854. | *Meiji*, | 1868. |

As no new year name ever came into use on the first of the year, but was generally introduced after the year was well advanced, the year of the end and commencement of a new period always had two year names.

The year 1890 was the 23d year of the *Meiji*, and its name was, therefore, *Ka no E Tora*, Metal elder brother tiger. The year 1892 is the 25th, and has the name *Tsuchi no E Tatsu*, Earth elder brother dragon.

The year was divided into months, which were real moons. They were numbered in serial order, and had no names like our months, except in poetry. There were twelve of these months, and, as they were all too short, a month was interpolated whenever the accumulated errors made the new year come a month too early, which was about every three years. The new year always came in the last of January or the first of February. The year was further divided into four seasons and into twenty-four minor periods, which were one-twenty-fourth of three hundred and sixty-five days each. These periods of about fifteen days each were called *sekki*. These *sekki* had appropriate names, such as

| | |
|---|---|
| *Risshun*, . . . . . | Early Spring. |
| *Kanro*, . . . . . | Cold Dew, |
| *Shokan*, . . . . . | Lesser Cold. |
| *Daikan*, . . . . . | Greater Cold. |

which were descriptive of the weather likely to occur during their continuance.

The division of the time into weeks was not known, nor was there anything which even in a remote way corresponds to it. Eastern nations generally claim great antiquity, and none are more tenacious in asserting their ancient origin than the Japanese, and none until recently were more conservative. More than one great artist, previous to the present reformation, has been invited to commit *hara-kiri* because of his supposed adoption of foreign ideas.

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Among these ancient nations time was recorded by "days," "months" and "years;" the "months" always commenced with the new moon, while "days" and "years" were computed from the movements of the sun. But as these months were only about twenty-nine and one-half days they could not be divided into periods of uniform length, and hence there could be no weeks. The only provision that could be made was the four phases of the moon, but these were not weeks. At the commencement of the present reign a holiday called *Ichi-roku* was introduced on all the ones and sixes of the month, making a division of the months into five parts, but it was so evidently only a copy of the western week that it was soon given up and our week took its place. Sunday is now everywhere kept as a day of rest from official work and is devoted to recreation, all the government offices being closed on that day. Sunday is called *Don-taku*, an evident corruption of the Dutch *Zontag*. The Saturday half-holiday has also been introduced in all the large cities, as one finds to his inconvenience when he does not happen to know it. Most places of business are closed on Saturday afternoon, which is called *Han-don* or Half-Sunday.

Time in Japan, except in the remote towns, is now recorded as in Europe. Foreign clocks and watches have now taken so firm a hold with the people that they will not be displaced. The Yankee clock is to be seen everywhere and has driven out other time-pieces. The names of the largest American manufacturers, printed or engraved on glass, is one of the ornaments of the watchmakers shops in almost every large city in Japan. The ancient methods are fast disappearing and with the introduction of the new the old is laid aside. The most interesting and valuable time-pieces constructed for keeping time by the ancient method can now be found in the curio shops and purchased for almost nothing, being discarded as no longer of use. They are models ordinarily taken from the Dutch time-pieces of the 17th century and are extremely interesting as relics of methods of recording time which have long ago disappeared and of escapements no longer used. For a historical horological museum a collection could be made in Japan for almost nothing, as, except among the curio dealers of the large towns, thronged by European visitors, the finest ancient time-pieces are of almost no value.

Their methods of computing time were very peculiar. The day was calculated from noon to noon and was divided into twelve

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hours, so that each hour was equal to two of ours. The hours of the most ancient nations were one-twelfth part of the day and night together or the time that a sign of the Zodiac takes in passing. These hour signs have always been twelve in number, because the sun traverses nearly a twelfth part of the ecliptic during each lunation. A single lunation was not evenly divisible, but two lunations made very nearly sixty days, a period which has from time immemorial been used by eastern nations. The division of the day into twelve hours which has been used from the earliest antiquity was adopted by the Japanese, but their counting of them was done in a singularly crab-like manner. Anciently the hours were not numbered, but were called after the names of animals. During the period of transition before the modern method was entirely adopted, numbers were used beside the animal names They were counted in a very peculiar way. Their relative values as compared with ours are given in the table below as they correspond to A.M. and P.M.

| Present Hours. | Old Japanese Hours. | Names of the P. M. Hours. After the signs of the Zodiac. | Names of the A. M. Hours. After the signs of the Zodiac. |
|---|---|---|---|
| 12<br>1 | 9. *Kokonotsu-doki.*<br>*Kokonotsu-han.* | *Uma*, the horse (Noon),<br>Half-past nine. | *Ne*, the rat (midnight),<br>Half-past nine. |
| 2<br>3 | 8. *Yatsu-doki.*<br>*Yatsu-han.* | *Hitsuji*, the goat,<br>Half-past eight. | *Ushi*, the bull,<br>Half-past eight. |
| 4<br>5 | 7. *Nanatsu-doki.*<br>*Nanatsu-han.* | *Saru*, the ape,<br>Half-past seven. | *Tora*, the tiger,<br>Half-past seven. |
| 6<br>7 | 6. *Mutsu-doki.*<br>*Mutsu-han.* | *Tori*, the cock,<br>Half-past six. | *U*, the hare,<br>Half-past six. |
| 8<br>9 | 5. *Itsutsu-doki.*<br>*Itsutsu-han.* | *Inu*, the dog,<br>Half-past five. | *Tatsu*, the dragon,<br>Half-past five. |
| 10<br>11 | 4. *Yotsu-doki.*<br>*Yotsu-han.* | *I*, the boar,<br>Half-past four. | *Mi*, the serpent,<br>Half-past four. |

The hours were reckoned from sunrise to sunset, there being always six hours between the two. The result was that the hours were never of the same length except for very short periods and then at the equinoxes. In winter the night hours were long and the day hours short, and in summer the day hours were long and the night hours short, and there was no way of averaging them, for sunrise and sunset were always six o'clock throughout the entire year.

Time was recorded by means of clocks and watches, in which

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there was but one hand, which indicated the hours. This hand was stationary, while the dial moved, except in clocks and watches with an alarm. There were no divisions of the hours into minutes and minutes were not known. On some very rare pieces a second hand was occasionally put upon the escape wheel as a matter of curiosity. The circle was moreover divided sometimes into six and sometimes into eight parts. The hand moved sometimes from left to right, and sometimes from right to left, and had no meaning. There was no occasion for the minute hand and the divisions of the hour were simply known as the half-hour, which half-hour was approximatively the value of our hour. Sometimes the spaces between the hours were divided into four or eight equal parts.

There were several methods of recording the time. These were those which were used on the person and those in the house. There is but little variation in the escapement of the time-pieces, but a great deal in the form. Almost all of them are copied from Dutch types of the 17th century. The escapements are almost universally verges or some modification of them, such as making the palates of the verge work upon the opposite sides of two escape wheels set vertically and facing each other; but few of this kind are seen. Occasionally the balance wheel makes the escapement move over the arc of a circle with a rack and pinion; these also are rare. Of those used upon the person there are three general varieties, all of them adapted to be worn in the *obi*, or sash which is one of the principal articles of both male and female attire. The Japanese dress has no pockets except in the sleeves, and articles of value could not be carried there; so everything is adapted to the *obi* or scarf worn round the waist in the ordinary Japanese dress. The watch with the ordinary verge escapement is sometimes with and sometimes without a striking part. It has sometimes a chain and sometimes a cat-gut on the barrel, but the chain is more common. The case in the striking watches is of very highly ornamented open work. The face is of gilt and the figures of silver. The single hand, as in all Japanese time-pieces without an alarm, is stationary and points to what would be our twelve o'clock, while the dial moves. The figures are all movable and are held to their places by springs on the back of the dial. The ring of the watch is fixed at right-angles to it, instead of parallel with it, as with us, in order to adapt it to the *obi*. The key is a very highly ornamental crank. The case is either round or eight-

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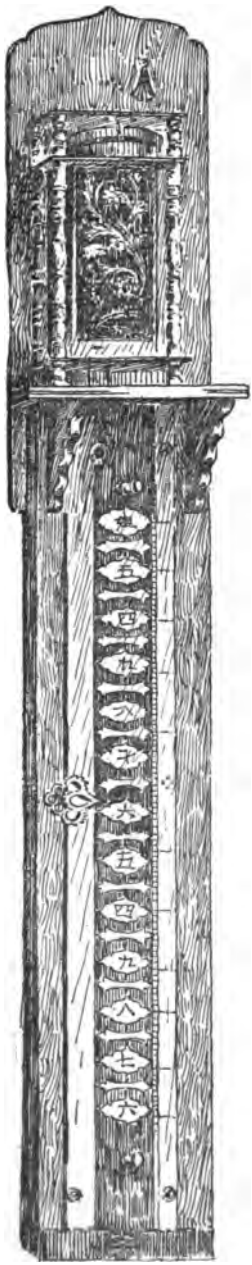
sided. The balance-wheel is generally of brass, but is sometimes of iron, and the pinions and pivots are all soft. The belt clocks, as they may be called, are rectangular and are about 2½ inches square, and ¾ of an inch thick. They are really diminutive brass clocks. They are either ornamented on the face with cloisonné or are very elaborately engraved. The escapements are verges, the balance-wheels are brass. They ordinarily have striking parts. The key is kept in a little drawer fastened to the bottom of the clock, or is attached to the cord which goes around it in the second method of attaching it. These are always covered with a wooden cage with a sliding door at the back, which is attached to the belt by means of an ornamented brass handle. The cases have glass on the front and sides and a highly ornamented wire gauze for one-third of the height on the side to let out the sound; or they are carried in a wooden case with a round glass in front, the top of which lifts off, but is attached to a string which goes around the whole case through holes made in the woodwork for the purpose, and to this the key is attached. This is fastened to the belt and is protected by a very highly ornamented leather case, which easily slips over the wooden one, which is generally carved. All of the brass work is highly ornamented.

FIG. 1.



The house clocks are of three kinds: those which are placed on a pyramid set on the floor in one corner of the room; those which hang on the wall; and those which are made to be placed in the *chigaidana* on a shelf which is a position of

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honor in the room. Those which are placed on a pyramid are arranged so as to be movable, but have a very large base in order not to be easily tipped over. The works are generally made of iron, and the case and works together are not over 30 to 35 inches in height. They usually show the months and the day of the month, and most of them have an alarm. They run for a little over 24 hours. The top part of the case is highly ornamented and the sides are divided into partitions, backed with silk, so as to let out the sound of the gong. The upper part also has openings which are covered with silks of different colors, or with a highly ornamented gauze. The object of the pyramid is simply to protect the weights.

Those which hang on the wall are made of highly ornamented brass. They have the weights free or enclosed in a case, and in common with all clocks, run about 24 hours. The escapements in all of these clocks are verges, and the balance is an arm with notches on it, on which movable weights are hung, so as to regulate the clock. When this disposition is used there are always two arms working on different escape-wheels attached to the same arbor, one for the day and one for the night, which are thrown into play by a cam at the proper time. The verges are suspended by silk and the stems run free in a hole below and have no pivot. These clocks have round dials, and always show the days of the month. They hang upon the wall by a hole made in the upper part of the clock case itself. The small wall clocks are of two kinds, according as they do or do not strike. The movement consists of four wheels, one of which sometimes has and sometimes does not have a hand which corresponds to our second hand. The circle, however, is divided only into six parts. They have no dial. The time is noted by a hand placed upon the weight, which indicates the hour, either on an engraved brass plate, Fig. 2, or by figures, or signs of the zodiac, which are attached to the front of the case, Fig. 1. The space between the hours is divided into ten parts on a separate brass scale. When such wall clocks have a striking part, this is placed in the weight, and is set off by a projection on the back of the figures. On the right hand side of such clocks there is sometimes a scale of ten equal parts which are each divided into ten so that the hour which corresponds to ours is divided into five equal parts. When the brass plate is engraved it is divided vertically to indicate the months of the year. This divi-

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sion reading from left to right is for the months, the word middle meaning the middle of the month,

| | | | | | | |
|---|---|---|---|---|---|---|
| Middle | | Middle | | Middle | | Middle |
| | December. | December. | October. | September. | September. | August. |
| November. | November. | October. | January. | January. | February. | February. |
| | Middle | | Middle | | | |
| August. | July. | July. | June. | | | |
| March. | March. | April. | April. | May. | May. | |

because at these times the hours were equal. A curve runs across them to give the hours, but as the hours are of different lengths in different seasons, the two vertical sides are graduated differently and the logarithmic curve which connects the two sides shows the variations of the hours. The brass plate is divided on the left with numbers which, commencing at the top are in the following order: 6, 5, 4, 9, 8, 7, 6, 5, 4, 9, 8, 7; and on the right hand side with the signs of the zodiac, commencing with *the cock*, which corresponds to 6, and ending with *the ape*, which corresponds to 7. The hand is attached to a loop fastened on to the weight and is moved horizontally over the plate to the month and, descending, points to the exact hour and divisions of the hour for that month. The following month it has to be moved to the next division and at the end of the year moved back again. The whole front of such clocks is movable and is kept in place by two brass pins. In such clocks as these there is always a small drawer in the bottom of the case to receive the key. Those which have no striking part are wound from the projection of the arbor on the barrel, as with us, which is always turned in spiral grooves to receive the cord. In those which have a striking part, it is wound, when the clock is wound up, from a hole in the case at the top. The works of these clocks are covered by a box from which the top and bottom is removed. They fit into a horizontal projection on the back of the clock, parallel to the clock case, and to others at the bottom at right angles to it, and are held in place at the top by a segment of a circle in brass, which moves on a pivot.

The shelf clocks are enclosed in highly ornamented brass cases. The sides and upper part of the case, and of the clock case itself, are ornamented with all the art for which in metal work the Japanese are so famous and have no superiors. Pieces of cloisonné of inlaid and repoussé metal of wire gauze to let out the sound of the bell, with curious forms of animals, flowers and trees, and every other

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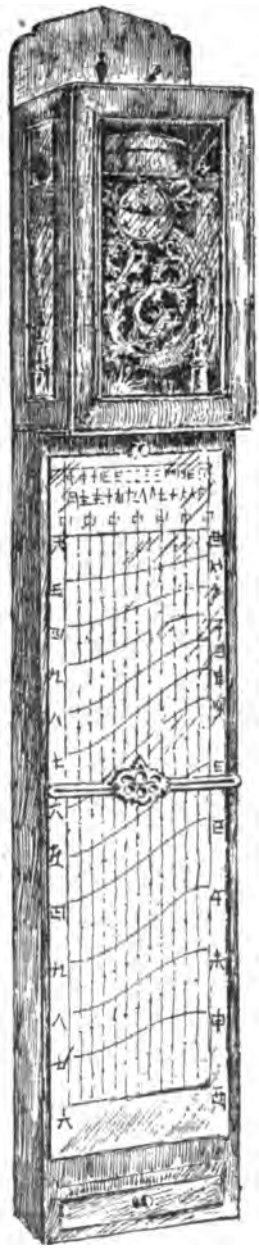
device which forms the ideas of beauty of these very interesting people. The clock is set upon a wooden base, and is enclosed in a case made of some hard wood, which is opened by two sliding doors, one at the front and one at the back. They are usually 0.18 m. high, and 0.14 m. wide and 0.10 m. deep. They are sometimes smaller than this, but rarely larger. They do or do not have an alarm. In the alarms the starting of the bell is done by a steel pin inserted in that part of the dial which represents the night hours, which, when it comes round to the hour, sets the alarm off. In this case the hand moves, but in all others the hand is stationary and the dial moves. The month and the day of the month are usually shown. These are placed either on the upper or lower part of the face, in which case the signs of the zodiac are on the left side, and the *jik-kan* on the right, or they are placed on the left side only, in which case the signs of the zodiac are above. In this case there is a third segment of a wheel with the signs long and short on it to indicate the character of the month. All of these move with the clockwork. The escapements are all verges and either have the arms with weights like the other clocks, one of these being used for the day and one for the night, or balance wheels. They are always placed in very highly ornamented wooden cases, either of ebony or some dark red wood, which are ornamented with gauze or cloisonné. The drawer for the key is sometimes in this outside case and sometimes in the wooden case attached to the bottom of the clock. The works are always of brass and sometimes are run by means

FIG. 2.



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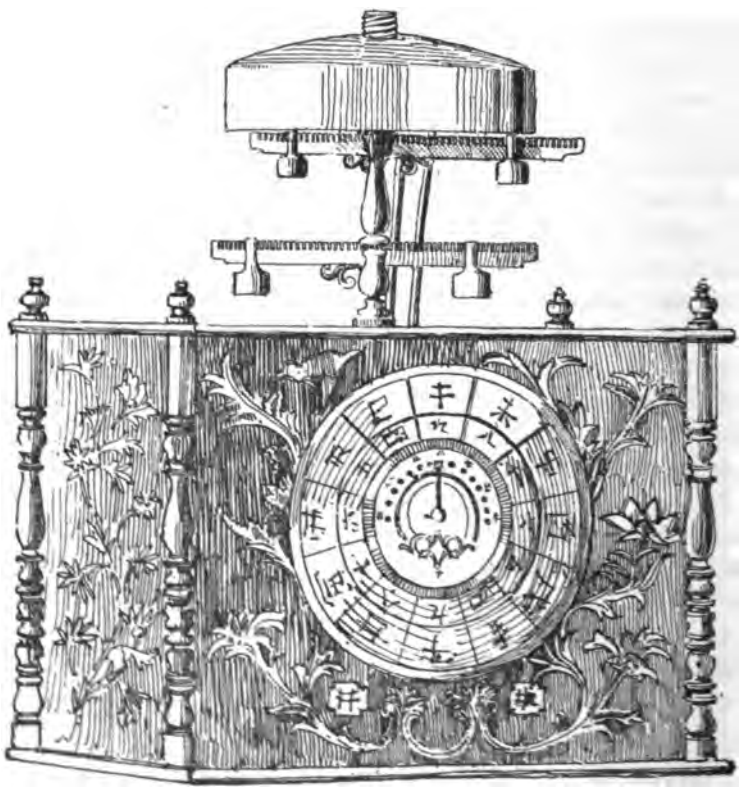
of a catgut and sometimes with a chain. The catgut used for the purpose is not like that which we use, but is twisted in strands like a string. The bell is always on top and the same bell serves for the alarm and for the striking parts, when there is one. The workmanship of these clocks is usually very fine, both as to the clockwork and the metal case in which they are placed, and the engraving on the outside of the brass work is very elaborate. As they

FIG. 3.



are simply curios now, they are not much esteemed by the Japanese and, except in the curio shops in the large cities, can be had for a very small price.

The locking plate of the striking part in the very old clocks is peculiarly cut. In all the older clocks the half hour between 9 and 8 is indicated by one stroke of the bell, but between 8 and 7 by two strokes. This gives at once the idea of the time, for if the

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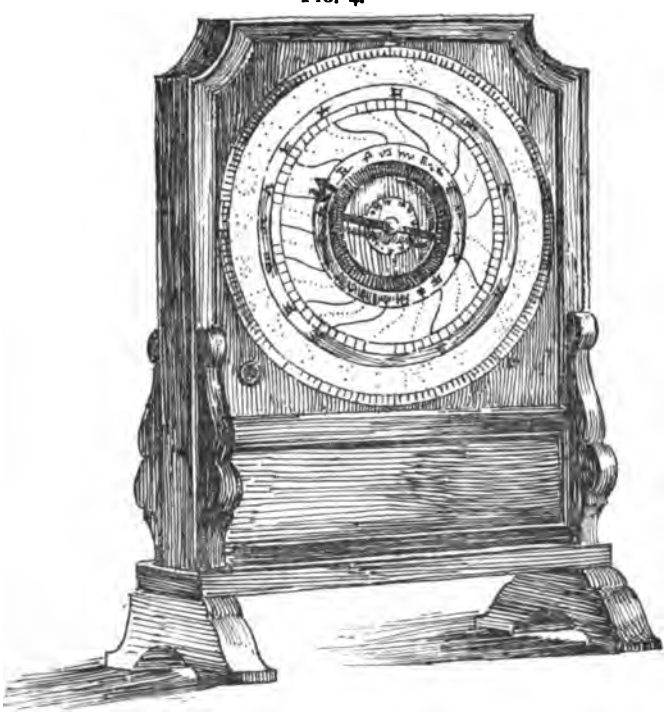
previous hour has been an odd number and the following one is to be consequently an even one, there will be but one stroke of the bell. If on the contrary the previous hour has been of an even number and the following is to be odd there will be two. In the more modern ones there is but one stroke between the hours.

When foreign ideas began to be adopted some of these clocks were sent to Switzerland, and were made to set off musical boxes at the hours, but while the works and cases of these clocks are usually of the finest description, the musical part is of the commonest kind.

FIG. 4.



I have one clock, Fig. 4, which shows on the outside of the dial the position of the constellations, next to them the figures on one side of the circle, the signs of the zodiac on the other, the logarithmic curve joining them. The hand is moved by the heart-shaped groove, so common in the clocks of the last century. It also shows the months, the days of the month, and the phases of the moon. It is set in a frame of dark-red hard wood called *shikan*, but it is a very uncommon form.

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Almost all of these clocks show the month and the cycle, which is shown on the front by wheels, which show through a square hole in the case the names of the cycle. One of these wheels is graduated to ten to show the *jik-kan*, and the other to the twelve, and shows signs of the zodiac. They move together so that the proper names are always shown.

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## DIGEST OF THE STUDIES MADE ON THE NATURE OF THE "ORGANIC NON-SUGAR" IN SACCHARINE PRODUCTS.

By J. A. DEGHUÉE, Ph.B., A.M.

The object of this work is to give a review of the studies that have been made and papers that have been written upon the subject of "Organic Non-Sugar" in saccharine products, preparatory to an investigation of the organic constituents of cane juices.

By far the greater amount of work done has been confined to beet-sugar products, the only articles of much importance found in regard to cane being those of Behr and Winter.

Altogether 60 organic compounds have been mentioned as existing in non-sugar. These have been divided into three classes:

1. Organic Acids, 33.
2. Nitrogenous Substances, 10.
3. Non-Nitrogenous Substances, 17.

They have been arranged in the form of an index, the different substances, in their respective classes, being placed in alphabetical order. Under the head of each substance are given, in the first column, the dates of publication arranged in chronological order, in the second column the reference numbers, and in the third a brief synopsis of the contents of the papers. These numbers, arranged in order, each with the reference to book or journal and title of paper given in full, will be found in the latter part of the work.

The books and journals consulted have been the following:

Die Zuckerarten und ihre Derivate, v. Lippmann; Handbuch der Kohlenhydrate, Tollens; Sugar Analysis, Wiechmann; Traité d'Analyse des Matiéres Sucrées, Sidersky; Untersuchungen über

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das Zuckerrohr, Winter; Sucre et Non-Sucre, Stammer; Zeitschrift des Vereins für Rübenzucker Industrie (complete); Neue Zeitschrift für Rübenzucker Industrie (complete); Sucre Indigéne et Coloniale (1882–1892, Vols. 19–38); Sugar Cane (complete); Berichte der Deutschen Chemischen-Gesellschaft (complete); Chemical News (complete); Chemiker Zeitung (1882 to 1892).

### Organic Acids.

Acetic, $C_2H_4O_2$; Aconitic, $C_6H_6O_6$; Adipic, $C_6H_{10}O_4$; Apoglucic, $C_{18}H_{10}O_9$; Arabic, $C_8H_{10}O_7$; Aspartic, $C_4H_7NO_4$; Butyric, $C_4H_8O_2$; Canna, $C_{14}H_{16}O_{13}$; Citric, $C_6H_8O_7$; Formic, $CH_2O_2$; Glucic, $C_{12}H_{18}O_9$; Glutamic, $C_5H_9NO_4$; Glutaric, $C_5H_8O_4$; Glutimic, $C_5H_7NO_3$; Glycollic, $C_2H_4O_3$; Glyoxalic, $C_2H_2O_3$; Humic, $C_{24}H_{10}O_{10}$; Lactic, $C_3H_6O_3$; Malic, $C_4H_6O_5$; Malonic, $C_3H_4O_4$; Melassic, $C_6H_6O_5$(?); Metapectic, $C_8H_{10}O_7.2H_2O$; Oxalic, $H_2C_2O_4$; Oxy-Citric, $C_6H_8O_8$; αOxy-Glutaric, $C_5H_8O_5$; Parapectic, $C_{24}H_{30}O_{21}$; Pectic, $C_{16}H_{18}O_{13}$ $2H_2O$; Propionic, $C_3H_6O_2$; Succinic, $C_4H_6O_4$; Sacculmic, $C_{44}H_{40}O_{16}$; Tartaric, $C_4H_6O_6$; Tricarballylic, $C_6H_8O_6$; Ulmic, $C_{20}H_{14}O_6$.

### Nitrogenous Substances.

Albumen; Asparagin, $C_4H_8N_2O_3$; Betain, $C_5H_{11}NO_2$; Cholin, $C_5H_{15}NO_2$; Glutamine, $C_5H_{10}N_2O_3$; Legumin; Leucin, $C_6H_{13}NQ_2$; Protagon; Trimethylamine, $C_3H_9N$; Tyrosin, $C_9H_{11}NO_3$.

### Non-Nitrogenous Substances.

Arabinose, $C_6H_{12}O_6$; Cholesterin, $C_{26}H_{40}O$; Coloring Matter; Coniferin, $C_{16}H_{22}O_8$; Dextran, $C_6H_{10}O_5$; Extractive Matter; Fats and Oils; Gummy Matter; Isocholesterin, $C_{26}H_{40}O_9$; Parapectin, $C_{32}H_{46}O_{31}$; Pararabin, $C_{12}H_{22}O_{11}$; Pectin, $C_{32}H_{48}O_{32}$; Pectose, $(C_2H_3O_2)_n$; Phytosterin, $(C_{26}H_{44}O)$?; Pyrocatechin, $C_9H_{10}O_4$; Vanillin, $C_8H_8O_3$; Viscose, $C_6H_{10}O_5$.

### Acetic Acid, $C_2H_4O_2$.

| Year. | Ref. No. | |
|---|---|---|
| 1875 | 93 | Birnbaum and Koken. Identified in the liquid from the save-all of the vacuum-pans. Prepared by extracting with ether, forming the ethyl ether and then fractioning. |

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| Year. | Ref. No. | |
|---|---|---|
| 1879 | 1 | BITTMANN. Not present in the untreated beet-juice. It is a product of fermentation. |
| 1885 | 44 | TEIXEIRA MENDES. Method of Determination. |
| 1891 | 58 | WINTER. Is found in cane-molasses. |
| | | ACONITIC ACID, $C_6H_6O_6$. |
| 1877 | 28 | BEHR. Discovered in cane-juice by Behr, 1877. Method of preparation. |
| 1879 | 1 | BITTMANN. Found both in cane and beet juices. |
| 1882 | 70 | PARSONS. Found in the pan incrustations of sorghum sugar-works. |
| | | ADIPIC ACID, $C_6H_{10}O_4$. |
| 1891 | 26 | v. LIPPMANN. Found in the calcium precipitate which is produced during the treatment of beet-juice. |
| | | APOGLUCIC ACID, $C_{18}H_{10}O_9$. |
| 1879 | 1 | BITTMANN. Produced by the action of alkali on glucose. |
| 1888 | 51 | WINTER. Found in cane-juice. |
| | | ARABIC ACID, $C_8H_{10}O_7$. |
| 1873 | 22 | SCHEIBLER. Discovered by Scheibler to be identical with metapectic acid. |
| 1879 | 64 | WACHTEL. Preparation and properties. (See also Lippmann, 56.) |
| 1880 | 36 | LIPPMANN. Usually found as a calcium salt. |
| | | ASPARTIC ACID, $C_4H_7NO_4$. |
| 1866 | 10 | SCHEIBLER. A decomposition product of asparagin. Method of preparation, properties, etc. |
| | | BUTYRIC ACID, $C_4H_8O_2$. |
| 1875 | 93 | BIRNBAUM AND KOKEN. Identified in the liquid from the save-all of the vacuum pans. Prepared by extracting with ether, forming the ethyl ether and then fractioning. |

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| Year. | Ref. No. | |
|---|---|---|
| 1879 | 1 | BITTMANN. Not present in untreated beet juice. It is a product of fermentation. |
| 1885 | 44 | TEIXEIRA MENDES. Method of determination. |
| 1891 | 58 | WINTER. Found in cane molasses. |

CANNA ACID, $C_{14}H_{16}O_{13}$.

| | | |
|---|---|---|
| 1891 | 58 | WINTER. Discovered by H. Winter, 1891. Preparation and properties. |

CITRIC ACID, $C_6H_8O_7$.

| | | |
|---|---|---|
| 1852 | 4 | MICHAELIS. Said to be present in beets prior to 1849. |
| 1879 | 1 | BITTMANN. Found in beets as a salt of an alkali or alkaline earth. |
| 1888 | 51 | WINTER. Thought not to be present in cane juice. |
| 1891 | 58 | WINTER. Not found in cane molasses. |

FORMIC ACID, $CH_2O_2$.

| | | |
|---|---|---|
| 1875 | 93 | BIRNBAUM AND KOKEN. Identified in the liquid from the save-all of the vacuum pans. Prepared by agitation with ether, forming the ethyl ether and then fractioning. |
| 1879 | 1 | BITTMANN. Not present in untreated beet juice. It is a product of fermentation. |
| 1885 | 44 | TEIXEIRA MENDES. Method of determination. |
| 1891 | 58 | WINTER. Not found in cane molasses. |

GLUCIC ACID, $C_{12}H_{18}O_9$.

| | | |
|---|---|---|
| 1839 | 99 | REICHARDT. Discovered by Peligot in a sucrate of calcium solution, which had decomposed on standing for several months. It was named potassium saccharic by him. Called "Glucic Acid" by Dumas. |
| 1874 | 97 | TEIXEIRA MENDES. Violet color sometimes found in beet juice due to the presence of an iron salt of glucic acid. |
| 1875 | 100 | BODENBENDER. Above confirmed. |



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| Year. | Ref. No. | |
|---|---|---|
| 1879 | 1 | BITTMANN. Produced by the action of alkali on glucose. |
| 1888 | 51 | WINTER. Found in cane juice by Winter. |
| | | GLUTAMIC ACID, $C_5H_9NO_4$. |
| 1869 | 15 | SCHEIBLER. Discovered by Scheibler 1869. |
| 1877 | 31 | BODENBENDER AND PAULI. Presence in beet juice confirmed. |
| 1884 | 71 | SCHEIBLER. Properties, etc. |
| | | GLUTARIC ACID, $C_5H_8O_4$. |
| 1891 | 26 | LIPPMANN. Discovered by Lippmann, 1891. Found in the calcium precipitate which is produced during the treatment of beet juice. |
| | | GLUTIMIC ACID, $C_5H_7NO_3$. |
| 1884 | 78 | LIPPMANN. Discovered by Lippmann, 1884. Identical with the "pyroglutamic acid" of Haitinger. |
| | | GLYCOLLIC ACID, $C_2H_4O_3$. |
| 1891 | 26 | V. LIPPMANN. Discovered by v. Lippmann, 1891. Found in the calcium precipitate which is formed during the treatment of beet juice. |
| | | GLYOXALIC ACID, $C_2H_2O_3$. |
| 1891 | 26 | LIPPMANN. Found in very young beets. |
| | | HUMIC ACID, $C_{24}H_{10}O_{10}$. |
| 1867 | 12 | SOSTMANN. Supposed to be a constituent of the red coloring matter of beet juice. Is an oxidation product of a colorless substance in the beet. |
| | | LACTIC ACID, $C_3H_6O_3$. |
| 1879 | 1 | BITTMANN. Not present in untreated beet juice. It is a product of fermentation. |
| 1891 | 58 | WINTER. Not found in cane molasses. |

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| Year. | Ref. No. | |
|---|---|---|
| | | MALIC ACID, $C_4H_6O_5$. |
| 1877 | 92 | SICKEL. Claimed to have been discovered by Payen and Braconnot. It is doubtful whether the compounds prepared by them were really malic acid. (See also Lippmann, 26.) |
| 1879 | 1 | BITTMANN. Found in the beet as a salt of an alkali or alkaline earth. |
| 1888 | 51 | WINTER. Identified in cane juice. |
| 1890 | 91 | LIPPMANN. Was known to exist in beets forty years ago. |
| 1891 | 26 | LIPPMANN. Found in the calcium precipitate which is produced during the treatment of beet juice. Preparation, properties, etc. Rotatory power. Only the lævo-variety is found. |
| | | MALONIC ACID, $C_3H_4O_4$. |
| 1881 | 65 | v. LIPPMANN. Discovered in incrustations of the vacuum pans by v. Lippmann; the first occurrence of this acid ready-formed in nature. Preparation, properties and analysis. |
| 1883 | 42 | v. LIPPMANN. Found in the concentrated juice of unripe or decomposed beets. |
| | | MELASSIC ACID, $C_6H_6O_3$ (?). |
| 1879 | 1 | BITTMANN. Produced by the action of an alkali on glucose. |
| | | METAPECTIC ACID, $C_8H_{10}O_7 2H_2O$. |
| 1852 | 4 | MICHAELIS. Determined by Michaelis in juice of beets prior to 1849. |
| 1868 | 13 | SCHEIBLER. Discovery credited to Fremy, 1860. (Compt. Rend., 48, p. 202). Produced by the action of acid or alkali on pectose. It is strongly lævo-rotatory. Is a glucoside. Sugar formed by its decomposition called "Pectinose." |
| 1873 | 22 | SCHEIBLER. Proved to be identical with arabic acid. Sometimes found in a soluble, sometimes in an insoluble form. |

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| Year. | Ref. No. | |
|---|---|---|
| 1888 | 80 | BATTUT. Lævo-rotatory when produced from pectose by the action of an alkali, dextro-rotatory when produced by the action of hydrochloric acid. In the latter case it reduces alkaline copper solution. |
| 1889 | 84 | WEISBERG. Converted into arabinose by sulphuric acid. |
| 1891 | 53 | HERZFELD. General properties. |

OXALIC ACID, $H_2C_2O_4$.

| | | |
|---|---|---|
| 1866 | 11 | SCHEIBLER. Discovered by Pelouze in 1831. (Dingler's Journ., vol. 43, p. 49). |
| 1879 | 1 | BITTMANN. Found in the beet as a salt of an alkali or alkaline earth. |
| 1888 | 51 | WINTER. Believed not to be present in cane-juice. |

OXY-CITRIC ACID, $C_6H_8O_8$.

| | | |
|---|---|---|
| 1883 | 42 | V. LIPPMANN. Discovered by v. Lippmann, 1883. Found in the concentrated juice of unripe beets. It is optically inactive, although it contains an asymmetric carbon atom. |

*α*OXY-GLUTARIC ACID, $C_5H_8O_5$.

| | | |
|---|---|---|
| 1882 | 39 | V. LIPPMANN. Discovered by v. Lippmann, 1882. |
| 1891 | 26 | V. LIPPMANN. Dextro-modification said to have been found in beet juice. |

PARAPECTIC ACID, $C_{24}H_{30}O_{21}2H_2O$.

| | | |
|---|---|---|
| 1852 | 4 | MICHAELIS. Determined in beets prior to 1849. |
| 1879 | 1 | BITTMANN. Is a conversion product of pectose. |
| 1890 | 52 | HERZFELD. Preparation, properties, etc. |

PECTIC ACID, $C_{16}H_{18}O_{13}2H_2O$.

| | | |
|---|---|---|
| 1879 | 1 | BITTMANN. Is a conversion product of pectose. |
| 1890 | 79 | SIDERSKY. Formed by the action of alkali on pectin. Converted into parapectic acid by heat or acids. |

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| Year. | Ref. No. | |
|---|---|---|
| | | PROPIONIC ACID, $C_3H_6O_2$. |
| 1879 | 1 | BITTMANN. Not present in untreated beet-juice. Is a product of fermentation. |
| | | SUCCINIC ACID, $C_4H_6O_4$. |
| 1879 | 1 | BITTMANN. Not normally present in beet-juice. May be produced by a kind of fermentation from asparagin or from malic acid. Is a constant product of alcoholic fermentation. |
| 1888 | 51 | WINTER. Found in cane juice by Winter. |
| 1891 | 26 | LIPPMANN. Found in the calcium precipitate which is produced during the treatment of beet-juice. |
| | | SACCULMIC ACID ($C_{44}H_{40}O_{16}$). |
| 1889 | 75 | DIGUET. Discovered by Sestini. First found in molasses by Diguet. Properties, etc. |
| | | TARTARIC ACID, $C_4H_6O_6$. |
| 1879 | 1 | BITTMANN. Its presence in beets not definitely determined up to 1879. |
| 1888 | 51 | WINTER. Believed not to be present in cane juice. |
| 1891 | 26 | LIPPMANN. Is found in the calcium precipitate which is formed during the treatment of beet juice. Also found in the juice of unripe beets. Optical properties, etc. Only the dextro variety is found. |
| | | TRICARBALLYLIC ACID, $C_6H_8O_6$. |
| 1878 | 32 | LIPPMANN. Discovered by v. Lippmann, 1878. Doubtful whether it is present normally in the beet juice or whether it is a product of decomposition of citric acid. |
| 1879 | 2 | WEHR. Supposed to be formed from citric acid. |
| | | ULMIC ACID, $C_{20}H_{14}O_6$. |
| 1867 | 12 | SOSTMANN. A constituent of the red coloring matter of beet juice, which is an oxidation product of a colorless substance in the beet. |

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| Year. | Ref. No. | |
|---|---|---|
| 1879 | 1 | BITTMANN. Produced by the action of an alkali on glucose. |
| 1888 | 51 | WINTER. Found in cane juice by Winter. |
| | | ALBUMEN. |
| 1852 | 4 | MICHAELIS. Determined in beets prior to 1849. |
| 1879 | 1 | BITTMANN. Found in beet-juice before treatment. Is laevo-rotatory. |
| | | ASPARAGIN, $C_4H_8N_2O_3$. |
| 1850 | 10 | SCHIEBLER. Discovery attributed to Rossigon. First mentioned by Dubrunfaut. |
| 1873 | 21 | SACHSSE. Proposal to determine the quantity by the amount of ammonia which is produced by its decomposition. |
| 1879 | 1 | BITTMANN. Not found in cane juice. |
| 1881 | 66 | BECKER. Optical properties. |
| 1890 | 79 | SIDERSKY. Is an amide of malic acid. Not precipitated by sub-acetate of lead. By heating with lime, it is decomposed into ammonia and aspartic acid. It is laevo-rotatory in alkaline solution, dextro-rotatory in acid solution. |
| | | BETAÏN, $C_5H_{11}NO_2$. |
| 1869 | 14 | SCHEIBLER. Discovered by Scheibler in 1866. Identity not established until 1869. Extracted by means of phospho-molybdate of sodium. When boiled with alkali, trimethylamine is formed. |
| 1870 | 16 | SCHEIBLER. The quantity varies greatly in different juices. Ripe beets contain less than the unripe. It is identical with oxyneurin. |
| 1877 | 85 | FRUEHLING AND SCHULZ. New method of preparation. |
| 1879 | 1 | BITTMANN. Not found in cane-juice. Does not act on polarized light. |
| | | CHOLIN, $C_5H_{15}NO_2$. |
| 1888 | 47 | LIPPMANN. Discovered by v. Lippmann, 1888. Preparation and analysis. |

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| Year. | Ref. No. | |
|---|---|---|
| | | GLUTAMINE, $C_5H_{10}N_2O_3$. |
| 1877 | 29 | SCHULZE AND URICHE. Discovered by Schulze and Uriche, 1877. The particular sample examined contained 0.45 per cent. |
| 1883 | 55 | SCHULZE AND BOSSHARD. Preparation, properties and analysis. Precipitated by mercuric nitrate. Is homologous with asparagin. |
| 1885 | 45 | SCHULZE AND BOSSHARD. Optical activity. |
| 1890 | 79 | SIDERSKY. Decomposed by heating with lime, into ammonia and glutamic acid. |
| | | LEGUMIN. |
| 1879 | 1 | BITTMANN. Found in untreated beet-juice. Is not coagulated on boiling. |
| | | LEUCIN, $C_6H_{13}NO_2$. |
| 1885 | 43 | V. LIPPMANN. Discovered by v. Lippmann, 1885. Optically active. Analysis, etc. Thought to be present in beet-juice long before the date of its discovery. |
| | | PROTAGON. |
| 1874 | 24 | SCHEIBLER. Discovered by Scheibler. |
| 1875 | 25 | JUBERT. Claim that substance discovered by Scheibler is a vegetable ferment. |
| 1876 | 27 | BORSCHTSCHOFF. Both theories refuted. |
| 1878 | 34 | CIENKOWSKI. Ferment theory supported. |
| | | TRIMETHYLAMIN, $C_3H_9N$. |
| 1879 | | Formed from Betain by the action of alkali and water. |
| | | TYROSIN, $C_9H_{11}NO_3$. |
| 1885 | 43 | LIPPMANN. Discovered by v. Lippmann in 1884. Analysis. Optical properties. Had been supposed to be present in beet-juice long before the date of its discovery. |

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| Year | Ref. No. | |
|---|---|---|
| | | ARABINOSE, $C_5H_{10}O_5$. |
| 1868 | 13 | SCHEIBLER. Discovered by Scheibler in 1868. He gave it the formula $C_{12}H_{12}O_{12}$ (old system). Called it "pectinose" or "pectin sugar." |
| 1880 | 36 | LIPPMANN. Formed by the action of sulphuric acid on arabic acid. (Also see Sidersky, 79). |
| 1884 | 86 | LIPPMANN. Properties, etc. |
| 1887 | 87 | LIPPMANN. Real formula found to be $C_5H_{10}O_5$. |
| 1889 | 88 | WOHL AND NIESSEN. Method of extraction from beets. |
| 1890 | 79 | SIDERSKY. Is dextro-rotatory. |
| 1891 | 89 | TOLLENS. Gives certain color reactions. |
| | | CHOLESTERIN, $C_{26}H_{40}O$. |
| 1874 | 24 | SCHEIBLER. Discovered by Scheibler, 1874. Found in an alcoholic extract of gelatinized beet-juice. |
| | | COLORING MATTER. |
| 1867 | 12 | SOSTMAN. First studied by Zier in 1839. |
| 1879 | 60 | v. WACHTEL. That of beets seems to act as an acid. |
| 1879 | 60 | WACHTEL. The outer part of the beet contains more chromogen than the inner. It is very unstable. Preparation and properties. Color was supposed to be formed by the iron knives used in cutting the beets. This is disproved. |
| 1879 | 63 | WACHTEL. Proof of the absence of iron and presence of nitrogen. |
| 1882 | 40 | STROHMER. Chromogen is called "Rhodogen" by Reinke. The coloring matter produced by the oxidation of this is called "Beta-red." The latter is believed to belong to the aromatic series. |
| | | CONIFERIN, $C_{16}H_{22}O_8$. |
| 1883 | 41 | LIPPMANN. Discovered by v. Lippmann in 1883. Found in the insoluble part of the beet. Produces vanillin on oxidation. |

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| Year. | Ref. No. | |
|---|---|---|
| 1890 | 79 | SIDERSKY. Gives a characteristic blue color with phenol. |

DEXTRAN, $C_6H_{10}O_5$.

| | | |
|---|---|---|
| 1874 | 24 | SCHEIBLER. Anhydride of glucose, sometimes found in beet-juice as a product of the life of the Schizomycetes, Leuconostoc Mesenteroides Cienk. |
| 1876 | 27 | BORSCHTSCHOFF. Is the main constituent of the gums of beet-juice. More like pectin than like a carbo-hydrate. |
| 1882 | 69 | BAUER. Origin and nature. |
| 1888 | 72 | WEISSBERG. Extraction. |
| 1888 | 51 | WINTER. Sometimes formed in cane-juice. |
| 1891 | 58 | WINTER. Found in cane-juice. |

EXTRACTIVE MATTER.

| | | |
|---|---|---|
| 1852 | 4 | MICHAELIS. Studied prior to 1849. |
| 1857 | 8 | MICHAELIS. Not completely precipitated by lead acetate. |

FATS AND OILS.

| | | |
|---|---|---|
| 1879 | 1 | BITTMANN. Only present in beet-juice in very small quantities. |

GUMMY MATTER.

| | | |
|---|---|---|
| 1855 | 7 | MICHAELIS. Claim that it is not found in the juice of uninjured beets. |
| 1876 | 27 | BORSCHTSCHOFF. Decided by Borschtschoff to be composed of non-nitrogenous bodies. Its principal constituent is dextran. |
| 1879 | 1 | BITTMANN. Very little definitely known. |

ISOCHOLESTERIN, $C_{26}H_{40}O_9$.

| | | |
|---|---|---|
| 1888 | 50 | KOLLREPP. Discovered by Kollrepp, 1888 Doubtful if the substance found is identical with the above. Preparation and properties. |

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| Year. | Ref. No. | |
|---|---|---|
| | | PARAPECTIN, $C_{32}H_{46}O_{31}$. |
| 1891 | 79 | SIDERSKY. Formed by heating pectin with water. Properties, etc. (See Pectin). |
| | | PARARABIN, $C_{12}H_{22}O_{11}$. |
| 1875 | 95 | REICHARDT. Discovered by Reichardt, 1875. Preparation and properties. |
| | | PECTIN, $C_{32}H_{48}O_{32}$. |
| 1852 | 4 | MICHAELIS. Determined in beet-juice prior to 1849. |
| 1855 | 7 | MICHAELIS. Claim that it is not found in the juice of uninjured beets. |
| 1888 | 51 | WINTER. Found in cane-juice by Winter. |
| 1888 | 73 | CHEVRON. Preparation and properties. |
| 1888 | 80 | BATTUT. Does not reduce Fehling's solution. Is dextro-rotatory. Converted into pectic acid by alkali. |
| 1889 | 76 | BEAUDET. Formation, etc. |
| 1889 | 77 | WEISBERG. Influence on the analysis of beet-juice. |
| 1891 | 53 | HERZFELD. Said to be a mixture of several compounds. |
| 1891 | 79 | SIDERSKY. Forms a gelatinous mass with water. Converted into metapectic acid by acids. |
| | | PECTOSE. |
| 1852 | 4 | MICHAELIS. Determined in beets prior to 1849. |
| 1879 | 1 | BITTMANN. Determined by conversion into pectic acid. |
| 1888 | 80 | BATTUT. General properties and action on polarized light. |
| 1890 | 79 | SIDERSKY. Converted into pectin as the beet ripens, it is supposed by the action of pectase. |
| | | PHYTOSTERIN, $C_{26}H_{44}O$. (?). |
| 1887 | 47 | v. LIPPMANN. Discovered by v. Lippmann, 1887. Separation and analysis. |

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| Year. | Ref. No. | |
|---|---|---|
| | | PYROCATECHIN, $C_9H_{10}O_4$. |
| 1888 | 48 | v. LIPPMANN. Discovered by v. Lippmann, 1888. Preparation, etc. |
| 1888 | 49 | WOHL. Has a strong reducing action on Fehling's solution. |
| | | VANILLIN, $C_8H_8O_3$. |
| 1880 | 54 | SCHEIBLER. Discoverered by Scheibler, 1880. Preparation and properties. |
| 1880 | 35 | v. LIPPMANN. Is the first benzol derivative ever found in sugar. |
| 1883 | 41 | v. LIPPMANN. Produced by the decomposition of coniferin. |
| | | VISCOSE, $C_6H_{10}O_5$. |
| 1881 | 67 | BÉCHAMP. Discovered by Béchamp, 1881. Preparation, properties and analysis. |
| 1881 | 68 | SCHEIBLER. Immediately proved to be identical with dextran. |

KEY TO LETTERS USED IN THE SECOND COLUMN OF THE REFERENCE INDEX.

A—Zeitschrift des Vereins für Rübenzucker Industrie.
B—Neue Zeitschrift für Rübenzucker Industrie.
C—Chemical News.
D—Berichte der Deutchen Chemischen Gesellschaft.
E—Chemiker Zeitung.
F—Sucrerie Indigéne et Coloniale.
G—Die Zuckerarten und ihre Derivate, v. Lippmann.
H—Berichte der Versuchstation für Zuckerrohr.
I—Untersuchungen über das Zuckerrohr.
K—Sugar Cane.
L—Liebig's Annalen.

| No. | Journal. | Title. |
|---|---|---|
| 1 | A 1879, v. 29, p. 882 | BITTMANN. Nachweisung und Bestimmung der Organischen Nichtzuckerstoffe der Salpetersäure und des Ammoniaks in Rübensäften, etc. |

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| No. | Journal. | Title. |
|---|---|---|
| 2 | A 1879, v. 29, p. 879 B 1879, v. 3, p. 160 | F. WEHR. Ueber das Vorkommen der Tricarballylsäure im Schlamme der Robert'schen Körper. |
| 3 | A 1879, v. 29, p. 1066 | V. LIPPMANN. Ueber das Vorkommen von Tricarballylsäure und Aconitsäure im Rübensaft. |
| 4 | A 1852, v. 2, p. 64 | MICHAELIS. Versuche zur Begründung des ihm patentirten Verfahrens, anlangend die Beseitigung des Verlustes an Zucker bei der Scheidung des Rübensaftes und die Gewinnung einer reineren Zuckermasse aus demselben. |
| 5 | A 1853, v. 3, p. 448 | MICHAELIS. Fortsetzung der Versuche zur Begründung des mir patentirten Verfahrens. |
| 6 | A 1855, v. 5, p. 61 | MICHAELIS. Fortsetzung der Versuche zur Begründung des mir patentirten Verfahrens. |
| 7 | A 1855, v. 7, p. 209 | MICHAELIS. Beziehungen der angestellten Versuche zu der Fabrikation des Rübenzuckers. |
| 8 | A 1857, v. 7, p. 39 | MICHAELIS. Nachträge zu der Vervollständigung der quantitativen Bestimmungen der Bestandtheile des Rübensaftes und Anleitung zur Analyse der Rübensäfte. |
| 9 | A 1864 v. 14, p. 726 | F. STÜDE. Ueber das Pectin. |
| 10 | A 1866, v. 16, p. 222 | SCHEIBLER. Beiträge zur näheren Kenntniss der organischen Bestandtheile des Rübensaftes. |
| 11 | A 1866, v. 16, p. 515 | SCHEIBLER. Beiträge zur näheren Kenntniss der organischen Bestandtheile des Rübensaftes. |
| 12 | A 1867, v. 17, p. 56 | SOSTMANN. Ueber den Farbestoff der Rübe. |
| 13 | A 1868, v. 18, pp. 159, 294 | SCHEIBLER. Untersuchungen über die Metapectinsäure der Zuckerrüben und über neue Eigenschaften derselben. |

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| 14 | A 1869, v. 19, p. 549<br>C 1869, v. 20, p. 107 | SCHEIBLER. Ueber das Betaïn, eine im Safte der Zuckerrüben vorkommende Pflanzenbase. |
| 15 | A 1869, v. 19, p. 553 | SCHEIBLER. Vorläufige Notiz über das Vorkommen einer mit der Asparaginsäure homologen neuen Säure in den Melassen der Rübenzucker Fabriken. |
| 16 | A 1870, v. 20, p. 20 | SCHEIBLER. Ueber das Betaïn und seine Constitution. |
| 17 | A 1870. v. 20, p. 208 | SCHEIBLER. Ueber den Betaïngehalt der Füllmassen und Melassen verschiedener Fabriken. |
| 18 | A 1870, v. 20, p. 339 | MARSCHALL. Ueber den Einfluss einiger organischer und unorganischer Salze auf das Krystallisationsvermögen des Rohrzuckers. |
| 19 | A 1870, v. 20, p. 352 | SCHEIBLER. Ueber das Vorkommen dextrinhaltiger Rohzucker und über die Nachweisung eines Dextringehaltes in denselben. |
| 20 | A 1871, v. 21, p. 322 | SCHEIBLER. Ueber die Nachweisung des Dextrins in den Rohzuckern. |
| 21 | A 1873, v. 23, p. 55 | SACHSSE. Ueber eine Methode zur quantitativen Bestimmung des Asparagins. |
| 22 | A 1873, v. 23, p. 288 | SCHEIBLER. Ueber normales Rübengummi und über das aus dem Rübensafte sich bildende Gährungsgummi. |
| 23 | A 1874, v. 24, p. 179 | SCHEIBLER. Ueber die Darstellung der Phospho-Wolframsäure als Fällungsmittel für organische Basen insbesondere zur Abscheidung des Betaïns aus Rübensäften. |
| 24 | A 1874, v. 24, p. 309 | SCHEIBLER. Untersuchungen über die Natur der gallertartigen Ausscheidung (sog. "Froschlaich"), welche bei der Saftgewinnung aus Rüben beobachtet wird. |
| 25 | A 1875, v. 25, p. 105 | JUBERT. Ueber das Gummi der Rübensäfte. |
| 26 | D 1891, v. 24, p. 3299 | v. LIPPMANN. Ueber organische Säuren aus Rübensaft. |

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| | B 1891, v. 27, p. 194<br>A 1892, v. 42, p. 137 | |
| 27 | A 1876, v. 26, p. 738 | BORSCHTSCHOFF. Die gallertartigen Substanzen der Rübensäfte und Syrupe. |
| 28 | A 1877, v. 27, p. 111<br>D 1877, v. 10, p. 351<br>C 1877, v. 35, p. 104 | A. BEHR. Ueber das Vorkommen von Aconitsäure im Zuckerrohrsaft und Colonialrohzucker. |
| 29 | A 1877, v. 27, p. 321<br>D 1877, v. 10, p. 85<br>B 1878, v. 1, p. 7 | SCHULZE u. URICH. Ueber die stickstoffhaltigen Bestandtheile der Runkelrüben. |
| 30 | A 1877, v. 27, p. 469 | FRÜHLING u. SCHULTZ. Neue Darstellung von Betaïn. |
| 31 | A 1877, v. 27, p. 965 | BODENBENDER u. PAULY. Ueber das Vorkommen einiger Säuren in der Melasse. |
| 32 | A 1878, v. 28, p. 365<br>D 1878, v. 11, p. 707<br>B 1879, v. 3, p. 179 | v. LIPPMANN. Ueber das Vorkommen von Tricarballylsäure im Rübensafte. |
| 33 | A 1878, v. 28, p. 804 | LAUGIER. Die Bestimmung einiger näherer Bestandtheile des Nichtzuckers in Rübensäften, Zuckern, u. s. w. |
| 34 | A 1878, v. 28, p. 1017 | CIENKOWSKI. Die Rübengallerte. |
| 35 | A 1880, v. 30, p. 134 | v. LIPPMANN. Ueber das Vorkommen von Vanillin in Rohzuckern. |
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| 37 | A 1880, v. 30, p. 647 | BODENBENDER u. IHLEE. Studien über die Formen des in der Melasse wie den Pro- |

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| | | ducten der Elution und im Rübensaft enthalten en Stickstoffs nebst Analysen des nach verschiedenen Methoden gewonnenen Zuckerkalks. |
| 38 | A 1882, v. 32, p. 883 | BAUER. Einiges über die Natur und Bildung von Dextran. |
| 39 | A 1882, v. 32, p. 895<br>B 1882, v. 8, p. 238 | v. LIPPMANN. Ueber das Vorkommen von αOxy-glutarsäure in der Melasse. |
| 40 | A 1882, v. 32, p. 879 | STROHMER. Ueber den Farbstoff der Zuckerrübe. |
| 41 | A 1883, v. 33, p. 316<br>D 1883, v. 16, p. 44<br>B 1883, v. 10, p. 43<br>E 1883, v. 7, pt. 1, p. 172 | v. LIPPMANN. Ueber das Vorkommen von Coniferin in den verholzten Geweben der Zuckerrübe. |
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| 43 | A 1885, v. 35, p. 156<br>D 1884, v. 17, p. 2835<br>B 1885, v. 14, p. 31 | v. LIPPMANN. Ueber das Vorkommen von Leucin und Tyrosin in der Rübenmelasse. |
| 44 | A 1885, v. 35, p. 250<br>B 1885, v. 14, p. 200 | TEIXEIRA MENDES. Nachweisung und Bestimmung der Ameisen-, Essig- und Buttersäure in der Melasse. |
| 45 | A 1885, v. 35, p. 319<br>D 1885, v. 18, p. 390 | SCHULZE u. BOSSHARD. Ueber das Vorkommen von Glutamin in den Zuckerrüben und über das optische Verhalten desselben. |

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| | B 1885, v. 14, p. 159<br>F 1885 v. 25, p. 551 | |
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| 47 | A 1888, v. 38, p. 68<br>D 1887, v. 20, p. 3201<br>B 1887, v. 19, p. 291 | v. LIPPMANN. Ueber einige organische Bestandtheile des Rübensaftes. |
| 48 | A 1888, v. 38, p. 455<br>D 1887, v. 20, p. 3298<br>B 1888, v. 20, p. 24 | v. LIPPMANN. Ueber eine im Rübenrohzucker vorkommende reducirende Substanz. |
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| 50 | A 1888. v. 38, p. 772 | KOLLREPP. Ueber einige organische Bestandtheile des Saturationsschlammes. |
| 51 | A 1888, v. 38, p. 780 | WINTER. Zur Kenntniss der chemischen Bestandtheile des Zuckerrohres. |
| 52 | A 1890, v. 40, p. 687. | HERZFELD. Parapectinsäure. |
| 53 | A 1891, v. 41, p. 667 | HERZFELD. Die Pectinsubstanzen der Rübe. |
| 54 | D 1880, v. 13, p. 335<br>B 1880, v. 4, p. 110 | SCHEIBLER. Vorkommen des Vanillins in gewissen Rübenrohzuckern. |
| 55 | D 1883, v. 16, p. 312 | SCHULTZE u. BOSSHARD. Ueber das Glutamin. |
| 56 | G 1882, p. 185 | v. LIPPMANN. Die Zuckerarten und ihre Derivate. |
| 57 | H 1890, p. 31 | WINTER. Zur Kenntniss der chemischen Bestandtheile des Zuckerrohres. |

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| 58 | I 1891, p. 18 | WINTER. Untersuchungen über das Zuckerrohr. |
| 59 | B 1879, v. 2, p. 376 | SCHEIBLER. Vorläufige Notiz über das Vorkommen optischlinksdrehender Stoffe in den Rübenmelassen. |
| 60 | B 1879, v. 2, p. 421 | WACHTEL. Der Rübenfarbstoff. |
| 61 | B 1879, v. 3, p. 128 | VAN TIEGHAM. Ueber die Rübengallerte. |
| 62 | B 1879, v. 3, p. 341 | SCHEIBLER. Vorläufige Notiz über das Vorkommen eines neuen, in den Rüben enthaltenen rechtsdrehenden Körpers und Verfahren der Nachweisung desselben mit Hülfe des mir patentirten Extractionsapparates. |
| 63 | B 1879, v. 3, p. 366 | v. WACHTEL. Ueber den Rübenfarbstoff. |
| 64 | B 1879, v. 3, p. 367 | v. WACHTEL. Die Arabinsäure in der Rübe. |
| 65 | B 1881, v. 6, p. 299 | v. LIPPMANN. Ueber das Vorkommen von Malonsäure in den Inkrustationen der Verdampfapparate. |
| 66 | B 1881, v. 6, pp. 304, 317 | BECKER. Ueber das optische Drehungsvermögen des Asparagins und der Asparaginsäure in verschiedenen Lösungsmitteln. |
| 67 | B 1881, v. 7, p. 214 | BECHAMP. Ueber die Viscose, ein gummiähnliches Product der schleimigen Gährung. |
| 68 | B 1881, v. 7, p. 216<br>F 1882, v. 19, p. 50 | SCHEIBLER. Ueber die Identität der Viscose mit Dextran. |
| 69 | B 1882, v. 8, p. 258 | BAUER. Die Natur und Entstehungsweise des Dextrans. |
| 70 | B 1882, v. 9, p. 87 | PARSONS. Aconitsäure im Kesselstein der Sorghum Zuckerpfannen. |
| 71 | B 1884, v. 13, p. 101 | SCHEIBLER. Untersuchungen über die Glutaminsäure. |



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| 75 | B 1888, v. 21, p. 212 | DIGUET. Versuche über schäumende und schwer zu verkochende Melassen. Ueber das Vorhandensein von Ulminsubstanzen in den Producten der Zuckerfabrication. |
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| 77 | B 1889, v. 23, p. 9 | WEISBERG. Ueber die in den Rüben enthaltenen Pectinsubstanzen und über die Rolle, welche dieselben bei der Fabrikation und der Analyse der Säfte spielen. |
| 78 | E 1884, v. 8, Pt. 1, p. 385 | v. LIPPMANN. |
| 80 | F 1888, v. 32, p. 285 p. 311 p. 357 | BATTUT. Contribution à l' étude des Composés pectiques. Leur influence sur la polarization des liqueurs sucrées. |
| 81 | F 1889, v. 33, p. 243 | BAUDET. Des Sels de Chaux et des Matières pectiques en Sucrerie. |
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| 83 | K 1874, v. 6, p. 256 | SCHEIBLER. On the presence of Arabic Acid in the Sugar Beet and on Arabin Sugar. |
| 84 | E 1889, v. 13, p. 2 | WEISBERG. Ueber die Pectinstoffe der Zukkerrübe. |
| 85 | A 1877, v. 27, p. 469 | FRÜHLING u. SCHULZ. Neue Darstellung von Betaïn. |
| 86 | A 1884, v. 34, p. 1383 | v. LIPPMANN. Ueber die Nichtidentität von Arabinose und Galactose. |
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| 88 | A 1889, | WOHL u. NIESSEN. Ueber die durch Erhitzen |

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| 89 | A 1891, v. 41, p. 907 | TOLLENS. Untersuchungen über Kohlenhydrate. |
| 90 | A 1892, v. 42, p. 137 | v. LIPPMANN. Ueber organische Säuren aus Rübensaft. |
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| 94 | L v. 67, p. 157 | PÉLIGOT. |
| 95 | A 1875, v. 25, p. 803 | REICHARDT. Pararabin, ein neues Kohlenhydrat. |
| 96 | 1887, | STAMMER. Sucre et Non Sucre. |
| 97 | A 1874, v. 24, p. 420 | TEIXEIRA MENDES. Ueber die Ursache des Nachdunkelns des Rübensaftes bei der Saturation. |
| 98 | A 1881, v. 31, p. 731 | KUTHE. Die Einwirkung des Chlorcalciums auf Melasse. |
| 99 | A 1870, v. 20, p. 529 | REICHARDT. Ueber die Zersetzungsproducte des Traubenzuckers bei Einwirkung starker Basen. |
| 100 | A 1875, v. 25, p. 122 | BODENBENDER. Zur Kenntniss einer Ursache der dunkeln Saturationssäfte. |

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## RECTIFICATION OF THE CRANK-PIN CURVE.

BY JAMES M. MCKINLAY.

NOTE.—Mr. James M. McKinlay who represents the Chicago, Milwaukee and St. Paul Railway Company at 42 Wall Street, New York, is interested in the locomotive crank-pin problem, and

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has succeeded by means of converging series in rectifying the curve described by the crank-pin. He sends the result in a particular case as being of interest to the readers of Mr. Trask's paper in the April issue of the QUARTERLY. Mr. McKinlay finds that a crank-pin at one-half foot from the centre of a wheel two and six-tenths feet in diameter describes a line 10,368 feet long, while the wheel rolls ten thousand feet.

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The equation of the crank-pin curve given in the April number of the QUARTERLY gives a differential for length of curve which cannot be integrated, as I believe, even when the lengths of radii are given in Arabic numerals.

By an equation obtained in the following manner, the curve can be rectified, provided the length of radii be given in Arabic numerals; but it requires a great deal of computation, and as it has to be calculated by series, the result is necessarily only approximate.

$x$ to be measured to the left from the origin.

$y$ to be measured downwards from the origin.

$\frac{a}{2}$ = radius of wheel.

$\frac{1}{2}$ = radius of crank-pin.

$s$ = sine, with diameter = 1.

$z$ = corresponding arc.

$x = s + az$.

$u$ = curve.

$s = (y - y^2)^{\frac{1}{2}}$.

$ds = \frac{1}{2}(y - y^2)^{-\frac{1}{2}}(1 - 2y)\,dy$.

$ds^2 = \frac{1}{4}(y - y^2)^{-1}(1 - 4y + 4y^2)\,dy^2$.

Add $dy^2 = \frac{1}{4}(y - y^2)^{-1}(4y - 4y^2)\,dy^2$.

$dz^2 = \frac{1}{4}(y - y^2)^{-1}\,dy^2$.

$adz = \frac{1}{2}(y - y^2)^{-\frac{1}{2}}\,ady$.

Add $ds = \frac{1}{2}(y - y^2)^{-\frac{1}{2}}(1 - 2y)\,dy$.

$dx = \frac{1}{2}(y - y^2)^{-\frac{1}{2}}(a + 1 - 2y)\,dy$.

$dx^2 = \frac{1}{4}(y - y^2)^{-1}(a^2 + 2a + 1 - 4ay - 4y + 4y^2)\,dy^2$.

Add $dy^2 = \frac{1}{4}(y - y^2)^{-1}(4y - 4y^2)\,dy^2$.

$du = \frac{1}{2}(\,|\,y + \frac{-2}{\frac{1}{2}}\,)a^2)y2a \quad + 1 - 4ay)^{\frac{1}{2}}dy$.

Now, if we take $a = 2.6$ $a^2 + 2a + 1 - 4ay$ becomes equal to $12.96 - 10.4y$.

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$$\text{Then } du = \tfrac{1}{2}\left(\frac{12.96 - 10.4y}{y - y^2}\right)^{\frac{1}{2}} dy$$

$$u = 3.6\int \frac{1}{2\sqrt{y}}\left(\frac{1 - \frac{1040}{1296}y}{1 - y}\right)^{\frac{1}{2}} dy.$$

In order to integrate this, $(1 - \frac{1040}{1296}y)^{\frac{1}{2}}$ has to be reduced to a series, and $(1 - y)^{-\frac{1}{2}}$ to another series. Their product gives a complicated slowly converging series.

By changing the equation to

$$u = 3.6\int \frac{1}{2\sqrt{y}}\left(\frac{(1 - \frac{1040}{1296}y)^{\frac{1}{2}} - \frac{16}{81}}{(1 - y)^{\frac{1}{2}}}\right) dy + 3.6\int \frac{\frac{16}{81}\,dy}{2(y - y^2)^{\frac{1}{2}}}$$

the series is made slightly more convergent.

The calculation gives $u = 10{,}368$ for 10,000 horizontal.

Equation of curve $x = \sqrt{y - y^2} + \frac{a}{2}\,vers^{-1}\,2y$.

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## POTASSIUM TETRAOXALATE AS A STANDARD IN ACIDIMETRY AND ALKALIMETRY.*

BY BERTRAND C. HINMAN.

TETRAOXALATE of potassium, $KHC_2O_4$, $H_2C_2O_4$, $2\,H_2O$ was originally proposed for this purpose by Ulbricht and Meissl, *Pharm. Centrh.* [N. F.], vi. 198, and commended by Kissling, in the *Zts. f. Angew. Chem.*, 1889, p. 332.

At the 1890 meeting of the Association of Official Agricultural Chemists (Eighth Annual Report, p. 24), it was adopted as the alternate substance for standardizing. At the meeting of 1891 (Ninth Annual Report, pages 131 and 153), it was the subject of considerable argument but was retained as the alternate for another year.

An investigation has been made of the properties of the salt with a view of determining its availability for this purpose.

The requisites for a substance to be used for standardizing are that it should be easily obtained pure, of definite chemical compo-

* A contribution from the Quantitative Laboratory of Columbia College.

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sition, that it should remain unaltered in the air, and react sharply with indicators.

Potassium tetraoxalate is soluble in forty parts of cold, and in six parts of boiling water (Storer, *Dic. Sol.*, p. 428).

Ignition converts it to $K_2CO_3$, so it would seem to be valuable for standardizing both acid and alkali solutions.

The formula given requires :

$(H_2O = 14.173$ per cent.)
Equivalent to $H_2C_2O_4 = 70.866$ per cent.
Equivalent to $K_2CO_3 = 27.165$ per cent.

It may be prepared by uniting solutions containing proper proportions of $K_2C_2O_4,2H_2O$, and $H_2C_2O_4,2H_2O$, crystallizing out and purifying by recrystallization. Three repetitions are said to be amply sufficient to produce a pure substance.

This method was followed, and an examination made of three lots of the salt, that crystallized four times, a mixture of that crystallized twice and thrice, and the crystals obtained from a concentration of the mother liquor.

Determinations of the oxalic acid in these samples were made by precipitation as $CaC_2O_4$, weighing as $CaSO_4$, and by titration with KOH standardized by the usual method.

The results were as follows :

| Sample. | Method. | Tetraoxalate taken. | Ca $SO_4$ found. | $H_2C_2O_4$ equivalent. | $H_2C_2O_4$ per cent. |
|---|---|---|---|---|---|
| Cryst. 4 times..... | Grav. | 0.7583 | 0.8224 | 0.54423 | 71.903 |
| " " ..... | " | 0.5528 | 0.6112 | 0.39712 | 71.837 |
| " " ..... | " | 0.6225 | 0.6759 | 0.44729 | 71.869 |
| " " ..... | Vol. KOH | 0.5296 | ..... | 0.3810 | 71.94 |
| " " ..... | " | 0.6821 | ..... | 6.4920 | 72.13 |
| " " ..... | " | 0.8105 | ..... | 0 5850 | 72.17 |
| Cryst. (2 and 3) times..... | " | 0.4578 | ..... | 0.3360 | 73.39 |
| " " ..... | " | 0.3921 | ..... | 0.2868 | 73 15 |
| Cryst. from Mother liquors... | " | 0.3546 | ..... | 0.2592 | 73.09 |

The salt was also tried by standard permanganate and gave results too high.

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All the samples analyzed are too acid by a little over one per cent., and the fewer the number of recrystallizations the greater is the excess of acid.

The mixed sample crystallized two and three times was again recrystallized three times and tested with the standard KOH. The percentage of oxalic acid was 73.32; apparently no change in composition had taken place.

An effort was made to determine the water of crystallization by heating the substance in an air-bath at given temperatures for specific times.

The following results were obtained:

| Sample. | Time of Heating, in hours. | Temp. ° C. | Weight taken. | Loss. | Per cent. of loss. |
|---|---|---|---|---|---|
| Cryst. 4 times..... | 3½ | 80 | 1.0433 | 0.1483 | 14.214 |
| " " ..... | 3½ | 100 | 1.0433 | 0.1504 | 14.416 |
| " " ..... | 3½ | 128 | 1.0433 | 0.1656 | 15.783 |
| " " ..... | 6 | 128 | 1.0090 | 0.1691 | 16.758 |
| " " ..... | 9 | 128 | 1.0090 | 0.1740 | 17.240 |
| " " ..... | 11 | 128 | 1.0090 | 0.1789 | 17.730 |
| " " ..... | 3 | 95 | 0.7527 | 0 0980 | 13.020 |
| Cryst. (2 and 3) times..... | 3½ | 80 | 1.2680 | 0.1768 | 13.936 |
| Cryst. 4 times..... | 3 | 100 | 0.7527 | 0.1103 | 14.680 |
| Cryst. (2 and 3 times..... | 3½ | 100 | 1.2680 | 0.1823 | 14.377 |
| " " " ..... | 3½ | 128 / 160 | 1.2680 | 0.2348 | 18.510 |
| " " " ..... | 6 | 128 | 1.0682 | 0.1683 | 15.755 |
| " " " ..... | 9 | 128 | 1.0682 | 0.1749 | 16.374 |
| " " " ..... | 11 | 128 | 1.0682 | 0.1789 | 16.728 |

These figures do not show a satisfactory result, and indicate that the combined water cannot be determined by heating.

Evidently a temperature of over 100° C. causes a decomposition, for in every instance at that temperature the salt lost more than its theoretical percentage of water of crystallization, and at somewhat higher temperatures the loss was considerable, and at a constant temperature increased with the time.

This phenomenon was easily perceptible at 128° C., at which

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temperature Borntträger (*Fres. Zts.*, xxxi., p. 43) says the salt must be heated to insure perfect drying.

Yet in these experiments it was found that eleven hours' heating at this temperature caused a loss of over 3½ per cent. more than the theory for water.

It is thus evident that the salt cannot be heated to this temperature without suffering decomposition.

In order to determine whether the apparent excess of water might be due to hygroscopic moisture, and whether or not the salt was efflorescent, a weighed portion in a tared dish was moistened with a few drops of distilled water and set aside in a dessicator over concentrated sulphuric acid.

After this treatment, if the dish with its contents should weigh less than it did before wetting, it would indicate either that the salt was non-efflorescent, and contained hygroscopic moisture, or that it was dry, but would effloresce in dry air.

But the dish rapidly regained its original weight, and remained persistently at that point for three days, at the end of which time the observations were discontinued.

Apparently then, the salt was dry, and was non-efflorescent.

From the results of the determinations of the equivalent oxalic acid, it would be expected if the water was out of proportion that it would be low, but experiment has shown that the equivalent oxalic acid and water are both high.

As a matter of fact not much faith is to be placed in the water determinations, for the experiments reasonably justify the belief that the estimation of the water of crystallization cannot be accurately made by determining the loss on heating.

The ignition of several samples of the salt, weighing and titrating the resulting $K_2CO_3$ with sulphuric acid (standardized by sodium carbonate) using methyl orange as an indicator, gave the following results:

| Sample. | Weight taken. | $K_2CO_3$ by weight. | $K_2CO_3$ per cent. | $K_2CO_3$ by titration. | $K_2CO_3$ per cent. |
|---|---|---|---|---|---|
| Cryst. four times..... | 1.0433 | 0.2817 | 27 000 | 0.2774 | 26.588 |
| " " ..... | 1.0090 | 0.2717 | 26.927 | 0.2732 | 27.076 |
| Cryst. (2 and 3) times..... | 1.2680 | 0.3430 | 27.050 | 0.3409 | 26.884 |
| " " " ..... | 1.0682 | 0.2890 | 27.083 | 0.2863 | 26.803 |

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The average of the percentages obtained by weighing is 27.015 and by titration 26.838.

These figures coinciding quite closely with the theoretical, and the acid being high indicates a curious balancing between acid and water. For if the $K_2O$ be correct and the acid high, then the water must be low. But as the water determinations could not be satisfactorily made by the method tried, this conclusion is unverified.

These results being so far at variance with theory, another sample of the substance was very carefully prepared in the same manner as the first and tested as before.

As usual, the purified salt after being filtered from the mother liquor was pressed between filter paper to remove the superfluous moisture, and then spread out on fresh paper in a layer not over a quarter of an inch thick and left to dry for three days.

In order to determine whether all the hygroscopic moisture had been removed by this treatment, a weighed portion of the material thus dried was placed in a tared dish, and allowed to remain in a dessicator over sulphuric acid for three days. The loss was 0.728 per cent. At the end of six days it was 1.23 per cent., and a week later or after having been in the dessicator for about two weeks, the loss amounted to 3.58 per cent. At the end of eight weeks there was a loss of 11.41 per cent.

The crystals had by this time assumed an opaque appearance, and efflorescence was clearly taking place.

Therefore it is clear that by this procedure a determination of the hygroscopic moisture is impossible, for the salt effloresces, and moreover the experiment seems to show a contradiction to the observation deduced from a previous experiment made under conditions almost similar when the tetraoxalate refused to part with any of its water of crystallization in a dessicator over sulphuric acid. The only difference between the two experiments was that the samples of salt operated upon were produced at different times, though the effort was in the second preparation to duplicate the method employed in the first.

This second preparation lost upon heating for three hours at 100° C., 14.370 per cent., but upon standing under a bell glass for several days it gained 1.466 per cent. of water from the air. Thus when the salt is nearly anhydrous it is deliquescent, and when containing its full amount of water of crystallization, its tendency is to effloresce.

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An average of three titrations of this second preparation with $^{n}/_{10}$ KOH gave an equivalent of 73.88 per cent. of oxalic acid, which is two per cent. more than was found in the first sample, and three per cent. more than theory calls for.

Upon ignition there was left a residue of $K_2CO_3$ amounting to 27.131 per cent., which is almost precisely the theoretical.

Careful tests for bases other than $K_2O$ gave negative results.

In the use of indicators for determining the end reaction in these titrations, there seems to be some doubt as to which of the many in use is the best.

The Association of Official Agricultural Chemists recommends methyl orange although it is generally accepted that it does not react sharply with organic acids, and upon trial the results were very uncertain.

Phenolphthalein works perfectly, and is certainly the best indicator for this purpose which is available, although litmus properly prepared is said to give good results. Coralline, or rosolic acid, cochineal or carminic acid, and congo red are of no value at all as indicators with oxalic acid.

As a result of these experiments it is clear that tetraoxalate of potassium, as prepared by the directions of those who advocate its use, is not a substance of constant composition.

The variations from the theoretical figures are so great as to entirely preclude its use as an agent for standardizing solutions for volumetric analysis.

This conclusion is justified by the preceding experiments, and finds verification by many who have investigated the subject.

In this connection may be quoted the remarks of Mr. William Frear on page 131 of the *Proceedings* of Eighth Annual Convention of the Association of Official Agricultural Chemists where he says: "The method by tetraoxalate of potash was not employed because it was found impossible to get a perfectly satisfactory salt, and because in our experience, even with dimethyl-anilin orange as an indicator, it was not possible to get a perfectly sharp end reaction. A tetraoxalate prepared under my directions last year by Dr. McDonnell by dissolving together the molecular proportions of chemically pure acid potassium oxalate and pure oxalic acid, gave after the fourth crystallization results showing it to possess an acidity 1.17 per cent. greater than that sent out by Dr. Caldwell for comparison of standards, and which both the latter and

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Mr. Scovell stated to agree exactly in strength with their acids standardized with $AgNO_3$.

Another sample obtained from Baker and Adamson when precipitated as $CaC_2O_4$ and weighed as CaO gave only 96.51 per cent. of the calculated amount of the latter oxide as a mean of three closely concordant determinations."

Further confirmation is found in the experiments of Mr. F. C. Wells (*Journal of Analytical and Applied Chemistry*, vol. vi., p. 192), who says, "Tetraoxalate of potassium possesses all the disadvantages that pertain to all the above mentioned reagents. It is harder to purify than soda, and it weathers as readily as oxalic acid."

It is evident then that the salt is indefinite in character, uncertain in quality, and cannot be prepared, by the methods given, of such purity as to be of service for the purpose for which it is recommended.

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## THE SPHEROMETER-CALIPER.*

BY THOMAS ARTHUR HUMASON, A.M.

THE spherometer-caliper is an instrument designed by Prof. Harkness, U. S. N., for measuring the inequalities and irregularities of pivots. The figures† show a front and side elevation. "The foundation-plate *b* carries two cylindrical guides, *dd*, which are connected at their lower end by the bar *e*. Into the foundation-plate is screwed the brass plate *m*, to which is cemented the thick circular glass plate *c*. Two V's, *aa*, are also screwed to the foundation-plate. The brass plate *f* slides freely up and down between the guides *dd*, being kept in place by three loops, two of which pass around the right-hand guide and one around the left, as shown in the figure. The brass rod *g*, which passes through the piece *m* and the plate *c* without touching either of them, is firmly attached to the upper end of the plate *f*, and moves with it, while to the lower end of *f* is attached a second short brass rod which passes freely through the bar *e* and carries the nut *h*."

"In using the instrument, the plate *f* is depressed by means of the nut *h* until one of the pivots whose irregularity is to be measured passes freely under the V's, *aa*. Then the V's having been properly adjusted upon the pivot, *h* is loosened and the flat edge

* Paper submitted in partial fulfilment of the requirements for Ph. D. degree, Columbia College.

† From Doolittle's *Astronomy*, by kind permission of John Wiley & Sons, publishers.

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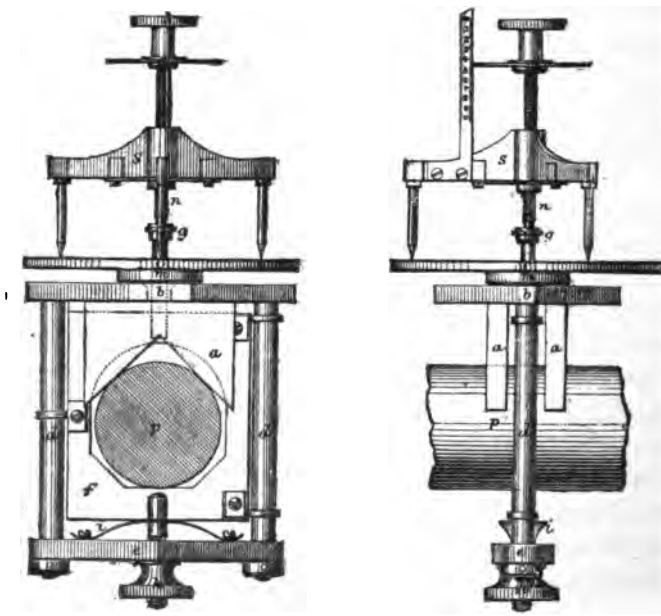
of the aperture in *f* is pressed against the under side of the pivot by the spring *i*. The elevation of the rod *g* above the glass plate is then measured by means of the spherometer. This consists of the micrometer screw shown in the figure, which is supported by the small tripod *s*, the legs of which rest on the glass plate. By means of this screw, small differences in the elevation of the rod *g*, and consequently of the size of the pivots, may be readily measured. To insure the greatest possible accuracy of measurement, the glass plate *c* must be entirely free from strain, and the flat surface of the opening *f* must be pressed with the same degree



of force against the under surfaces of the two pivots Both these conditions are evidently fulfilled in the construction of the instrument; and as an additional precaution, the top of the rod *g* is capped by a carefully ground agate, upon which the point of the spherometer screw rests.*

In the instrument belonging to the Columbia College Observatory, the flat edge of the aperture in the plate *f* consists of a bar which can be adjusted to any desired height upon the plate, and thus the instrument is rendered capable of measuring pivots of any diameter from 2½ inches down to the smallest size.

To find the relation between the difference of the two readings

* Prof. Harkness, *Monthly Notices*, vol. xxxviii., p. 488 *et seq.*

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of the spherometer and the inequality of the pivots upon which they were made, let*

2 v = the angle of the V's *aa*;

n = the difference between the readings of the screw on the two pivots;

R = the linear distance between two consecutive threads of the screw;

L = the distance between the V's of the transit instrument;

p = the inequality of the pivots expressed in seconds of time;

r = the radius of the pivot to be measured;

C = the distance from the upper surface of the glass plate to the angle of the V's.

Then the vertical distance from the upper surface of the glass plate to the flat surface of the aperture in *f* will be

$$C + r + \frac{r}{\sin v} = C + r\left(\frac{1 + \sin v}{\sin v}\right) \quad . \quad (1).$$

Similarly for the other pivot

$$C + r'\left(\frac{1 + \sin v}{\sin v}\right) \quad . \quad . \quad . \quad . \quad (2).$$

The difference is

$$(r - r')\left(\frac{1 + \sin v}{\sin v}\right) \quad . \quad . \quad . \quad (3).$$

This is evidently the difference in the elevation of the end of the rod *g* when the second pivot is substituted for the first; that is, the difference between the two micrometer readings. Therefore:

$$(r - r')\left(\frac{1 + \sin v}{\sin v}\right) = n\,R; \quad . \quad . \quad (4).$$

$$r - r' = \frac{n\,R \sin v}{1 + \sin v}, \quad . \quad . \quad . \quad (5).$$

which is the inequality of the radii of the pivots expressed linearly. To convert it into seconds of time it must be divided by L. 15 tan 1″ and thus we obtain finally

$$p = n\,\frac{R \sin v}{L\,(1 + \sin v)\,15\,\tan 1''} \quad . \quad . \quad . \quad (6).$$

The spherometer-caliper of the Columbia College Observatory was made by Fauth & Co., of Washington. An examination of its essential features showed that the glass surface is well ground and very nearly smooth. The spherometer is very light, the frame being made of German silver and the legs of steel, the whole weighing only about one ounce and a half.

* Prof. Harkness, *Monthly Notices*, vol. xxxviii., pp. 489-90.

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"The screw is rendered entirely free from dead motion by a supplementary nut immediately below the main one, and attached to the frame of the instrument by three elastic arms so arranged that any required strain can be put upon them. The spherometer screw passes through both these nuts, and by carefully adjusting the tension on the arms of the supplementary one, which is two or three threads below the other, the two can be so pressed toward each other as to eliminate all dead motion, and yet leave the movement of the screw as light as may be desired."* The legs of the spherometer were found to be of unequal length and their points at unequal distances from the centre, and these errors were corrected by the makers before the instrument was put in use. At the same time it was found advisable to have small weights attached to two of the arms in order to counterbalance the weight of the reading scale which is attached to the third arm. This places the centre of gravity in the screw and renders the instrument much more delicate.

The pitch of the micrometer screw was found by measuring the length of certain metal standards of known length, in terms of the revolutions of the micrometer screw, after first establishing the true zero of the instrument by taking its reading on a plane surface. I am indebted to Prof. Harkness for the use of his standards and to the Director of the United States Naval Observatory for access to the observatory and the use of a plane glass surface, the property of the Government.

The following are readings taken at the United States Naval Observatory upon Prof. Harkness' brass standards, using as a plane surface, mirror No. VI., made by Alvan Clark and Sons, which has a radius of curvature of 12.3 miles. Great care was taken in handling the standards and placing them upon the plane surface to avoid all accidental errors. The length of the standards at 70° F. had been determined to be: A = 0.25993 inches and B = 0.49874 inches. Temperature changed during the observations from 74.4° to 76.0° F. and was not taken into account. In the first column following are the lengths of the standards in terms of the revolutions of the micrometer screw of the spherometer. The second column marked v contains the residual errors of the several observations, and the third column marked vv the squares of those residual errors:

* Prof. Harkness, *Monthly Notices*, vol. xxxviii., p. 492.

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| STANDARD A. | | | | STANDARD B. | | |
|---|---|---|---|---|---|---|
| Obs. | Revolutions. | v. | vv. | Revolutions. | v. | vv. |
| 1 | 25.006 | 0.000 | .000000 | 49.926 | +.007 | .000049 |
| 2 | 25.006 | .000 | 0 | 49.929 | +.010 | 100 |
| 3 | 25.004 | —.002 | 4 | 49.927 | +.008 | 64 |
| 4 | 25.008 | +.002 | 4 | 49.930 | +.011 | 121 |
| 5 | 25.007 | +.001 | 1 | 49.927 | +.008 | 64 |
| 6 | 25.007 | +.001 | 1 | 49.928 | +.009 | 81 |
| 7 | 25.007 | +.001 | 1 | 49.929 | +.010 | 100 |
| 8 | 25 005 | —.001 | 1 | 49.927 | +.008 | 64 |
| 9 | 25.006 | .000 | 0 | 49.926 | +.007 | 49 |
| 10 | 25.007 | +.001 | 1 | 49.929 | +.010 | 100 |
| 11 | 25.003 | —.003 | 9 | 49.925 | +.006 | 36 |
| 12 | 25.000 | —.006 | 36 | 49.924 | +.005 | 25 |
| 13 | 25.001 | —.005 | 25 | 49.921 | +.002 | 4 |
| 14 | 24.999 | —.007 | 49 | 49.920 | +.001 | 1 |
| 15 | 25.005 | —.001 | 1 | 49.923 | +.004 | 16 |
| 16 | 25.004 | —.002 | 4 | 49.922 | +.003 | 9 |
| 17 | 25.003 | —.003 | 9 | 49 920 | +.001 | 1 |
| 18 | 25.004 | —.002 | 4 | 49.926 | +.007 | 49 |
| 19 | 25.004 | —.002 | 4 | 49.921 | +.002 | 4 |
| 20 | 25.005 | —.001 | 1 | 49.924 | +.005 | 25 |
| 21 | 25.008 | +.002 | 4 | 49.922 | +.003 | 9 |
| 22 | 25.009 | +.003 | 9 | 49.923 | +.004 | 16 |
| 23 | 25.010 | +.004 | 16 | 49 920 | +.001 | 1 |
| 24 | 25.007 | +.001 | 1 | 49.922 | +.003 | 9 |
| 25 | 25.007 | +.001 | 1 | 49.917 | —.002 | 4 |
| 26 | 25.006 | .000 | 0 | 49.922 | +.003 | 9 |
| 27 | 25.010 | +.004 | 16 | 49.918 | —.001 | 1 |
| 28 | 25.009 | +.003 | 9 | 49 918 | —.001 | 1 |
| 29 | 25.009 | +.003 | 9 | 49.914 | —.005 | 25 |
| 30 | 25 008 | +.002 | 4 | 49.921 | +.002 | 4 |
| 31 | 25.009 | +.003 | 9 | 49.926 | +.007 | 49 |
| 32 | 25.007 | +.001 | 1 | 49.927 | +.008 | 64 |
| 33 | 25.006 | .000 | 0 | 49.927 | +.008 | 64 |
| 34 | 25 010 | +.004 | 16 | 49.927 | +.008 | 64 |
| 35 | 25.009 | +.003 | 9 | 49.926 | +.007 | 49 |
| 36 | 25.006 | +.000 | 0 | 49.922 | +.003 | 9 |
| 37 | 25.009 | +.003 | 9 | 49.925 | +.006 | 36 |
| 38 | 25 009 | +.003 | 9 | 49.926 | +.007 | 49 |
| 39 | 25.007 | +.001 | 1 | 49.922 | +.003 | 9 |
| 40 | 25.012 | +.006 | 36 | 49.926 | +.007 | 49 |
| 41 | 25.007 | +.001 | 1 | 49.899 | —.020 | 400 |
| 42 | 25 001 | —.005 | 25 | 49 901 | —.018 | 324 |
| 43 | 25 002 | —.004 | 16 | 49.897 | —.022 | 484 |
| 44 | 25.002 | —.004 | 16 | 49.901 | —.018 | 324 |
| 45 | 24.999 | —.007 | 49 | 49.899 | —.020 | 400 |
| 46 | 25.000 | —.006 | 36 | 49.905 | —.014 | 196 |
| 47 | 25 002 | —.004 | 16 | 49.900 | —.019 | 361 |
| 48 | 25 000 | —.006 | 36 | 49.901 | —.018 | 324 |
| 49 | 25.004 | —.002 | 4 | 49 898 | —.021 | 441 |
| 50 | 25.009 | +.003 | 9 | 49.900 | —.019 | 361 |
| Mean | = 25.0057 | [vv] = | .000522 | Mean = 49.9191 | [vv] = | .005098 |

Mean error of arithmetical mean = .000462, Mean error of arithmetical mean = .001442.
Probable error of arithmetical mean = .000311. Probable error of arithmetical mean = .000973.

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The value of one revolution of the screw by standard A would be 0.010395 inches, and by standard B, 0.009991 inches.

The wide disagreement in the readings as indicated in the above table led to an examination of the standards. Under a microscope they were found to be in poor condition, there being several indentations and other irregularities in the surface of each. Accordingly, as the above results could not be taken as conclusive, measurement was made of two new steel standards (quarter-inch and half-inch respectively), made by Pratt and Whitney, and also the property of Prof. Harkness.

The following (p. 347) are lengths of the steel standards in terms of revolutions of the micrometer screw. The temperature varied from 74° to 75° F. during the observations and was not taken into account:

Standard C gives the value of one revolution of the micrometer screw as 0.010002 inches and standard D, 0.0099997 inches.

Combining the results of the readings on the four standards, assigning to each a weight inversely proportional to the square of its mean error (viz., giving the readings on standard A the weight 9, on standard B the weight 1, on standard C the weight 136, on standard D the weight 40), we obtain for the value of one revolution of the micrometer screw,

$$R = 0.0100204 \text{ inches.}^*$$

The micrometer head is divided into 100 parts and hence the value of one division is 0.0001 inches. In use, readings can be made accurately within $\frac{2}{10}$ of a division at the most, and consequently differences can be distinguished accurately as small as .00002 inches in a single observation.

*Comparison of the Pivots of the Rutherfurd Transit Instrument (Stackpole No. 1518) of the Columbia College Observatory.*

The Rutherfurd transit instrument has been in use over twenty years, and for a number of years it has been used frequently by students. It was therefore not to be expected that the pivots would be in perfect condition.

* The readings of these results indicate that there may be a slight change of pitch in the screw. It is certainly not large enough to affect the small differences which occur in the comparison of pivots.

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| Obs. | STANDARD C. Revolutions. | v. | vv. | STANDARD D. Revolutions. | v. | vv. |
|---|---|---|---|---|---|---|
| 1 | 24,994 | —.001 | .000001 | 50.003 | +.002 | .000004 |
| 2 | 24.995 | .000 | 0 | 50.002 | +.001 | 1 |
| 3 | 24.996 | +.001 | 1 | 50.004 | +.003 | 9 |
| 4 | 24.994 | —.001 | 1 | 50.003 | +.002 | 4 |
| 5 | 24.996 | +.001 | 1 | 50.001 | +.001 | 1 |
| 6 | 24.996 | +.001 | 1 | 50.003 | +.002 | 4 |
| 7 | 24.995 | .000 | 0 | 50.004 | +.003 | 9 |
| 8 | 24.995 | .000 | 0 | 50.002 | +.001 | 1 |
| 9 | 24.995 | .000 | 0 | 50.004 | +.003 | 9 |
| 10 | 24.995 | .000 | 0 | 50.004 | +.003 | 9 |
| 11 | 24.998 | +.003 | 9 | 50.002 | +.001 | 1 |
| 12 | 24.995 | .000 | 0 | 50.004 | +.003 | 9 |
| 13 | 24.995 | .000 | 0 | 50.004 | +.003 | 9 |
| 14 | 24.995 | .000 | 0 | 50.003 | +.002 | 4 |
| 15 | 24.994 | —.001 | 1 | 50.003 | +.002 | 4 |
| 16 | 24.995 | .000 | 0 | 50.001 | .000 | 0 |
| 17 | 24.994 | —.001 | 1 | 49.999 | —.002 | 4 |
| 18 | 24.994 | —.001 | 1 | 50.001 | .000 | 0 |
| 19 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 20 | 24.995 | .000 | 0 | 50.001 | .000 | 0 |
| 21 | 24.995 | .000 | 0 | 50.002 | +.001 | 1 |
| 22 | 24.994 | —.001 | 1 | 50.002 | +.001 | 1 |
| 23 | 24.994 | —.001 | 1 | 50.002 | +.001 | 1 |
| 24 | 24.995 | .000 | 0 | 50.002 | +.001 | 1 |
| 25 | 24.994 | —.001 | 1 | 50.002 | +.001 | 1 |
| 26 | 24.994 | —.001 | 1 | 50.002 | +.001 | 1 |
| 27 | 24.994 | —.001 | 1 | 50.002 | +.001 | 1 |
| 28 | 24.995 | .000 | 0 | 50.003 | +.002 | 4 |
| 29 | 24.995 | .000 | 0 | 50.001 | .000 | 0 |
| 30 | 24.993 | —.002 | 4 | 50.002 | +.001 | 1 |
| 31 | 24.994 | —.001 | 1 | 50.002 | +.001 | 1 |
| 32 | 24.994 | —.001 | 1 | 50.000 | —.001 | 1 |
| 33 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 34 | 24.994 | —.001 | 1 | 50.000 | —.001 | 1 |
| 35 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 36 | 24.995 | .000 | 0 | 49.999 | —.002 | 4 |
| 37 | 24.995 | .000 | 0 | 49.998 | —.003 | 9 |
| 38 | 24.995 | .000 | 0 | 50.001 | —.000 | 0 |
| 39 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 40 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 41 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 42 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 43 | 24.994 | —.001 | 1 | 50.000 | —.001 | 1 |
| 44 | 24.995 | .000 | 0 | 50.000 | —.001 | 1 |
| 45 | 24.994 | —.001 | 1 | 50.000 | —.001 | 1 |
| 46 | 24.996 | +.001 | 1 | 50.000 | —.001 | 1 |
| 47 | 24.996 | +.001 | 1 | 50.001 | .000 | 0 |
| 48 | 24.994 | —.001 | 1 | 50.000 | —.001 | 1 |
| 49 | 24.996 | +.001 | 1 | 50.001 | .000 | 0 |
| 50 | 24.996 | +.001 | 1 | 50.001 | .000 | 0 |
| Mean | = 24.99484 | [vv] = | .000036 | Mean = 50.00144 | [vv] = | .000122 |

Mean error of arithmetical mean, = .000121.
Probable error of arithmetical mean, = .000082.

Mean error of arithmetical mean, = .000223.
Probable error of arithmetical mean, = .000150.



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Following are comparisons of the pivots in 36 different positions at intervals of 10° throughout the circumference. The zero of the spherometer is easily affected. Accordingly, while the observations were taken at different times, the measurement of the two pivots in a given position was invariably made in quick succession and under similar circumstances.

The mode of making these measurements was as follows: The transit instrument was put on its reversing carriage so that the pivots were free, and turned in the desired position. Then the caliper was slipped on the pivot and adjusted so that the glass plate was level, after which the spherometer was placed upon it and very carefully read. This process was repeated several times at each observation.

Each of the quantities in the following list is the mean of a number of readings taken with every effort to render them independent and accurate. It will be noticed that the measurements are arranged in pairs in positions 180° apart. The position of the pivots marked 0° is that when the telescope is pointed north, clamp west. The number of degrees increases 10°, 20°, 30°, etc., to 360°, as the telescope is revolved upward from its original position. In each case, it will be remembered, the caliper is in a vertical position.

The second column contains the measurements of the clamp pivot in revolutions of the micrometer screw, and the third column that of the lamp pivot. The fourth column contains the differences in revolutions.

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| Position of Pivot. | Clamp Pivot. (Revolutions.) | Lamp Pivot. (Revolutions.) | n. (Revolutions.) | Position of Pivot. | Clamp Pivot. (Revolutions.) | Lamp Pivot. (Revolutions.) | n. (Revolutions.) |
|---|---|---|---|---|---|---|---|
| 0° | 127.037 | 127.044 | .007 | 60° | 127.013 | 127.033 | .020 |
| | .020 | .020 | .000 | | .038 | .052 | .014 |
| | .049 | .050 | .001 | | .042 | .050 | .008 |
| | .021 | .025 | .004 | | | | |
| | .03175 | .03475 | .003 | | .031 | .045 | .014 |
| 180° | .037 | .072 | .035 | 240° | .043 | .071 | .028 |
| | .040 | .071 | .031 | | .041 | .062 | .021 |
| | .038 | .060 | .022 | | .030 | .050 | .020 |
| | .012 | .033 | .021 | | | | |
| | .03175 | .059 | .02725 | | .038 | .061 | .023 |
| 10° | .020 | .026 | .006 | 70° | .040 | .047 | .007 |
| | .022 | .031 | .009 | | .040 | .047 | .007 |
| | .020 | .018 | —.102 | | .040 | .047 | .007 |
| | .02066 | .025 | .00433 | | .040 | .047 | .007 |
| 190° | .040 | .070 | .030 | 250° | .027 | .047 | .020 |
| | .037 | .054 | .017 | | .027 | .047 | .020 |
| | .035 | .072 | .037 | | .027 | .047 | .020 |
| | .03733 | .06533 | .028 | | .027 | .047 | .020 |
| 20° | .026 | .022 | —.004 | 80° | .041 | .045 | .094 |
| | .027 | .036 | .009 | | .041 | .045 | .004 |
| | .020 | .019 | —.001 | | .041 | .045 | .004 |
| | .02433 | .02566 | .00133 | | .041 | .045 | .004 |
| 200° | .039 | .066 | .027 | 260° | .025 | .043 | .018 |
| | .037 | .055 | .018 | | .025 | .043 | .018 |
| | .033 | .070 | .037 | | .025 | .043 | .018 |
| | .03633 | .06366 | .02733 | | .025 | .043 | .018 |
| 30° | .013 | .023 | .010 | 90° | .040 | .045 | .005 |
| | .026 | .038 | .012 | | .023 | .031 | .008 |
| | .048 | .053 | .005 | | .044 | .050 | .006 |
| | .029 | .038 | .009 | | .03566 | .042 | .00633 |
| 210° | .038 | .071 | .033 | 270° | .029 | .044 | .015 |
| | .038 | .059 | .021 | | .016 | .035 | .019 |
| | .041 | .064 | .023 | | .025 | .044 | .019 |
| | .039 | .06466 | .02566 | | .02333 | .041 | .01766 |
| 40° | .013 | .015 | .002 | 100° | .040 | .045 | .005 |
| | .028 | .038 | .010 | | .040 | .045 | .005 |
| | .048 | .049 | .001 | | .040 | .045 | .005 |
| | .02966 | .034 | .00433 | | .040 | .045 | .005 |
| 220° | .041 | .071 | .030 | 280° | .030 | .048 | .018 |
| | .038 | .060 | .022 | | .030 | .048 | .018 |
| | .025 | .045 | .020 | | .030 | .048 | .018 |
| | .03466 | .05866 | .024 | | .030 | .048 | .018 |
| 50° | .042 | .052 | .010 | 110° | .042 | .046 | .004 |
| | .026 | .030 | .013 | | .042 | .046 | .004 |
| | .014 | .023 | .009 | | .042 | .046 | .004 |
| | .02733 | .038 | .01066 | | .042 | .046 | .004 |
| 230° | .040 | .059 | .019 | 290° | .033 | .052 | .019 |
| | .041 | .071 | .030 | | .033 | .052 | .019 |
| | .030 | .048 | .018 | | .033 | .052 | .019 |
| | .037 | .05933 | .02233 | | .033 | .052 | .019 |

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| Position of Pivot. | Clamp Pivot. (Revolutions.) | Lamp Pivot. (Revolutions.) | n. (Revolutions.) | Position of Pivot. | Clamp Pivot. (Revolutions.) | Lamp Pivot. (Revolutions.) | n. (Revolutions.) |
|---|---|---|---|---|---|---|---|
| 120° | 127.050 | 127.070 | .020 | 150° | 127.047 | 127.070 | .023 |
| | .041 | .059 | .018 | | .039 | .061 | .022 |
| | .045 | .071 | .026 | | .043 | .071 | .028 |
| | .04533 | .06666 | .02133 | | .043 | .06731 | .02433 |
| 300° | .043 | .051 | .008 | 330° | .045 | .048 | .003 |
| | .044 | .055 | .011 | | .045 | .049 | .004 |
| | .043 | .051 | .008 | | .045 | .052 | .007 |
| | .04333 | .05233 | .009 | | .045 | .04966 | .00466 |
| 130° | .053 | 070 | .017 | 160° | .040 | .072 | .032 |
| | .042 | .061 | .019 | | .039 | .061 | .022 |
| | .048 | .071 | .023 | | .046 | .073 | .027 |
| | .04766 | .06733 | .01966 | | .04166 | .06866 | .027 |
| 310° | .043 | .051 | .008 | 340° | .040 | .034 | —.006 |
| | .047 | .063 | .016 | | .043 | .039 | —.004 |
| | .041 | .048 | .007 | | .045 | .051 | .006 |
| | .04366 | .054 | .01033 | | .04266 | .04133 | —.00133 |
| 140° 1′ | .045 | .073 | .028 | 170° | .046 | .071 | .025 |
| | .042 | 060 | .018 | | .039 | .060 | .021 |
| | .048 | .073 | .025 | | .040 | .070 | .030 |
| | .045 | .06866 | .02366 | | .04166 | .067 | .02533 |
| 320° | .048 | .053 | .005 | 350° | .047 | .050 | .003 |
| | .048 | .050 | .002 | | .042 | .048 | .006 |
| | .045 | .048 | .003 | | .049 | .050 | .001 |
| | .047 | .05033 | .00333 | | .046 | .04933 | .00333 |

A glance at the preceding comparisons shows that the two pivots differ not only in size but in shape. Accordingly, another set of observations was taken to see whether either pivot was round. The following is the summary of those observations in condensed form. These readings are taken at intervals of 45°, and on one pivot in different positions consecutively, the intention being to make a comparison, not between the two pivots, but between different positions of the same pivot.

| Position of Pivot. | Clamp Pivot. Reading. | Lamp Pivot. Reading |
|---|---|---|
| 0° | 127.022 | 127.025 |
| 180° | 127.012 | 127.033 |
| 45° | 127.024 | 127.032 |
| 225° | 127.014 | 127.034 |
| 90° | 127.023 | 127.032 |
| 270° | 127.014 | 127.035 |
| 135° | 127.020 | 127.034 |
| 315° | 127.021 | 127.028 |

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These readings show plainly that neither pivot is round, or elliptical, but each is irregular, the clamp pivot probably being more irregular than the lamp pivot. The spherometer-caliper cannot determine the amount of these irregularities as I shall now proceed to show.

In the *Monthly Notices of the Royal Astronomical Society*, vol. xxxviii, pp. 488–493, Prof. Harkness describes the construction and working of the instrument, gives some examples of its use in the United States Naval Observatory, and claims for it the following advantages over the spirit level: "1. It is more accurate; 2, it shows the exact form of each pivot; 3, it is at least ten times more expeditious." A somewhat similar claim is made for the instrument in *Doolittle's Practical Astronomy*, p. 302, where the author says: "This instrument is especially to be recommended in examining the pivots for irregularities, as by measuring different diameters of the pivot the exact form may be determined."

In regard to the latter claim it is only necessary to say that a glance at the instrument will show that it is wholly incapable of measuring or comparing *diameters*, and even if it could, an infinite number of diameters could not determine the shape of the pivot.

Let us refer to equation (1) in the theory of the instrument, the expression for the distance from the glass surface to the bottom of the aperture in f.

$$C + r + \frac{r}{\sin v} = C + r\left(\frac{1 + \sin v}{\sin v}\right)$$

This is manifestly true in only one case, namely, when the pivots are exactly round or when the three radii concerned in any given reading are precisely equal. Formulæ (2), (3), (4), (5) and (6) which follow from this are likewise true in only the one case. Place an irregular pivot in the caliper and the reading will be different in different positions, as in the readings quoted above. In this case there are three distances, which we may call radii for want of a better name, upon which each reading depends. Moreover these radii are entirely independent of each other, must necessarily differ from each other, and except in two positions, do not meet in a point.

Let us see what these formulæ will become when an irregular pivot is placed in the caliper. The accompanying figure repre-

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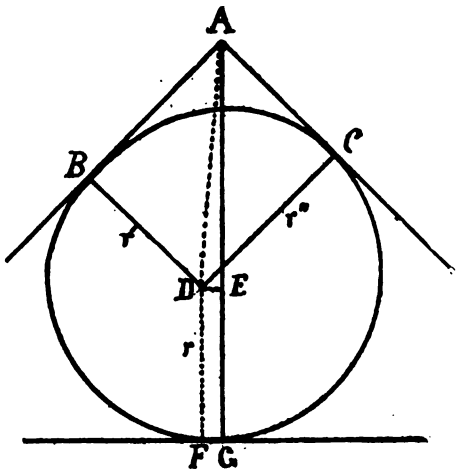
sents the caliper upon a pivot worn on one side. We wish to find an expression for the distance from the vertex of the V's A to the bar at G. Let D be the point of intersection of the perpendiculars




from the two points of tangency, B and C. Let us call the distance D F, $r$; the distance B D, $r'$, and the distance C D, $r''$.

Then:

$$A\,G = r + \tfrac{1}{2}\,(r' + r'')\,\sqrt{2}.$$

Similarly for the other pivot or another position of the same pivot:

$$A\,G_1 = r_1 + \tfrac{1}{2}\,(r_1' + r_1'')\,\sqrt{2}.$$

For the difference between two readings of the spherometer we should then have:

$$n\,R = r - r_1 + \tfrac{1}{2}\,[(r' + r'') - (r_1' + r_1'')]\,\sqrt{2}.$$

In this expression, $r$, $r_1$, $r'$, $r_1'$, $r''$ and $r_1''$, are different in each position of the pivots, and as their mathematical relation cannot be ascertained, the solution of the equation is impossible.

In order to consider more closely the working of the instrument I quote the following from Prof. Harkness's article in the *Monthly Notices*, vol. xxxviii, p. 491.

This is an example of work done with the spherometer-caliper

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upon a Stackpole transit instrument in the United States Naval Observatory.

| Position of Pivot. | Clamp Pivot. | Lamp Pivot. | n. | p. |
|---|---|---|---|---|
| 180°, . . . | 43.2347 | 43.2180 | 0.0167 | 0.051 |
| 225°, . . . | 43.2370 | 43.2223 | 0.0147 | 0.045 |
| 270°, . . . | 43.2367 | 43.2173 | 0.0194 | 0.059 |
| 315°, . . . | 43.2377 | 43.2143 | 0.0234 | 0.071 |

Prof. Harkness states: "Upon reducing these measurements my first impression was that the large value of $p$ at 315° must have been erroneous, and I remeasured the pivot inequality at that point, with the result $p = 0.''075$. This confirmed the first measurement, and showed beyond all possibility of doubt that one, or perhaps both of the pivots were elliptical. An examination of the spherometer readings upon the clamp pivot proves that it is round, at least within the limits of error of observation, but with the lamp pivot the case is different. The largest spherometer reading upon it is at 225° and the smallest at 315°. These are, therefore, the approximate positions of the major and minor axes of the ellipse. The difference of the spherometer readings at these points is $0''.0080$. *Substituting this in equation* (5) we find that the semi-major axis exceeds the semi-minor one by 0.000089 cm.—a small quantity truly, but one about which there can be no doubt."

It will be noticed that Prof. Harkness here (as in the other example quoted in the article) has taken readings in only four positions of the pivots. If he had taken measurements in positions differing from these by 180° he would probably have found that readings in opposite directions in the same position of the pivot would give different results, showing that the pivot was of irregular shape. Instead of this, however, finding a larger reading in one position than in the others, he called the pivot elliptical with the major axis vertical when the largest reading was obtained. This was a possible interpretation of his readings. But in order to find out the linear difference between the semi-major and semi-minor axes, he substitutes in equation (5) which, as I have shown, is true only when the pivot is round.

Granting that his pivot is elliptical, let us see how much his result is in error. As the V of his caliper has an angle of 90° its vertex is at a constant distance from the centre of the elliptical pivot. Letting $a$ = the semi-major, and $b$ = the

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semi-minor axis, this distance would be $\sqrt{a^2 + b^2}$ in all positions of the pivot. Letting the distance from the top of the glass plate to the vertex of the V be represented, as before, by C, we should have for the distance from the top of the glass plate to the bar at the bottom of the pivot, when the major axis is vertical,

$$C + \sqrt{a^2 + b^2} + a.$$

Similarly when the minor axis is vertical,

$$C + \sqrt{a^2 + b^2} + b.$$

The difference in the spherometer reading $n\,R$ in these two positions would therefore be the difference between these two quantities, or:

$$n\,R = a - b.$$

In other words, in this case, the difference between the semi-major and semi-minor axes is equal to the difference between the spherometer readings in the two positions. In Prof. Harkness' instrument $R = 0.02697$ cm. and the difference of spherometer readings $n = 0^r.0080$. Therefore:

$$a - b = 0.00021576 \text{ cm.}$$

The semi-major, therefore, exceeds the semi-minor axis by 0.00021576 cm. instead of 0.000089 cm., as Prof. Harkness concludes by the use of his formulæ.

Since the error of a result obtained by the use of the spherometer-caliper upon an elliptical pivot, using the formulæ which Prof. Harkness has derived, is so large, it is not likely that the error would be less upon a pivot of irregular shape. In the latter case, however, we could not determine the amount of the error, as can be done in the case of an elliptical pivot, because, as has been shown, no formulæ can be derived which are applicable to irregularities.

It seems probable that Prof. Harkness's pivot is not elliptical. There are an infinite number of irregular shapes which would fit his readings just as well as an ellipse. Moreover, an irregular shape would be much more probable. In use the wear is nearly all on one side. So that, even if the pivot be round or elliptical at first, it must in time become irregular.

What, then, is the use of the spherometer-caliper? In the first

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place, if both pivots are exactly round the instrument will tell the linear difference between the radii of the two pivots and the level correction to be applied. This is a rare case, for, while in a new transit instrument the pivots may be round, the weight of the telescope, bearing almost always on the same side of the pivots, will in time wear them on that side and they will become irregular.

Secondly, the instrument will show whether or not the pivot is round. But even to accomplish this a much longer process than that used by Prof. Harkness would be necessary. A measurement in four positions shows next to nothing. We can, in the measurements of the Rutherfurd transit, printed above, select readings in four positions which would, by Prof. Harkness's process of reasoning, indicate that both pivots were round. Yet we know that they are not. Before the pivots could be declared round there would be necessary, at least, measurements in eight positions at intervals of 45° throughout the circumference, and in order to make the conclusion free from doubt readings should be taken in no less than thirty-six positions at intervals of 10°. If these agreed precisely one would then be warranted in pronouncing the pivot round. If a similar agreement was obtained in all positions of the other pivot, it would be quite proper to proceed to determine the difference, in the manner indicated by Prof. Harkness.

Thirdly, the instrument can detect the presence of irregularities, but it cannot determine the amount of those irregularities, nor can it show with accuracy their location.

I am, therefore, driven to the conclusion that the spherometer-caliper is useless for the very purpose for which it has been claimed to be the most valuable.

As regards the interpretation of the readings taken upon the pivots of the Rutherfurd transit instrument, there is but little to be said. Neither pivot is round, but both have irregularities. These irregularities are greater in the clamp pivot than in the lamp pivot, and are probably not in corresponding positions on the two pivots. The lamp pivot is larger than the clamp pivot, the average difference in reading being 0.0142 revolutions, but as the actual difference of reading between the two pivots changes with every change of position (in one place, at 340°, the reading on the clamp pivot is the larger), it is not safe to take this average difference as a basis to determine the level correction for any given position.

The question now arises, can the spherometer be used to deter-

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mine the level correction for irregularities? During my investigation of the spherometer-caliper in its present form, there occurred to me a plan for an instrument which I believe would accomplish the desired result and at the same time possess all the advantages of the present instrument. The plan of the instrument is as follows: Instead of the bar which forms the lower edge of the aperture in *f* (see Fig., p. 1) construct a device for holding, in an upright position, the detached V of the transit instrument, Then, when the pivot is inserted in the caliper, instead of being pressed upward by a straight bar it will be pressed by its own V, and the pivot and V will occupy precisely the same relative positions that they assume when the transit instrument is in actual use.

The V's of the caliper, *aa*, should be replaced by a single V. The angle of this V should be made to correspond exactly with the angle of the V's of the striding level. The rest of the instrument might remain as at present, except for such changes as the above conditions would necessitate.

The advantages of this form of instrument are apparent. When the pivot is in the caliper, all points of contact between the pivot and the transit V below, and the pivot and the caliper V above are precisely the same as though the transit instrument were in actual use, the pivots resting in their own V's, and the striding level resting upon them. The level correction for inequality in any position would then be the actual difference between the two pivots in that position as indicated by the spherometer-reading, the difference being changed to time. Moreover this correction would be wholly independent of the shape of the pivot, being equally true, whether the pivot be round, elliptical or irregular.

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# METHODS OF MODERN PETROGRAPHY.

By LEA McI. LUQUER, C.E.

THIS article is intended to be a continuation and completion of the work commenced by Mr. H. Hensoldt, formerly of the School of Mines, and published in the SCHOOL OF MINES QUARTERLY, vol. x., p. 212; vol. xi., p. 29; and vol. xii., p. 132.

Several unsuccessful attempts have been made to obtain from Mr. Hensoldt the unfinished portion of his article on "Methods of Modern Petrography," but there seems to be no prospect of ever getting from him the desired information. I have therefore decided, at the request of the editors, to put on record the methods used in the Mineralogical Laboratory of Columbia College, treating the subject in somewhat more detail than is generally done in text-books. At the same time I wish to state that Mr. Hensoldt is not responsible for anything contained in this article.

The following apparatus and methods of work have been fully described by Mr. Hensoldt in the SCHOOL OF MINES QUARTERLY.

The grinding bench (Hensoldt model), used both for cutting and grinding.

Diamond saws, and how to make and charge them.

Laps for grinding, with advantages of having them made of copper instead of lead or iron.

Method of mounting specimen for cutting by horizontal saw, and preparation of gum used in mounting.

Method of cutting specimen by the horizontal saw.

Method of finishing one side of section and cementing it to glass plate for grinding down.

In addition to the grinding bench (Hensoldt model), with the saw or lap revolving in a horizontal plane, there is, in the mineralogical laboratory, a cutting machine with the saw revolving in a vertical plane. The advantage of the second type of machine over the first is the ease and security with which a specimen can be held by clamps, so that sections can be cut from it in any direction. On this second type of machine there is also a screw adjustment, so arranged as to make it possible to cut strictly parallel sections. The disadvantage is that the vertical saw throws

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water badly, while with the horizontal saw (Hensoldt model) all the water is caught in a tin tray. See vol. xii., p. 135. Another disadvantage in the vertical type of machine is that it cannot be used for both grinding and cutting.

A third type of machine is used by the United States Geological Survey at Washington, D. C. It consists of an endless soft iron wire, about $\frac{3}{32}$ inches in diameter, revolving over two pulleys or wheels, one of which is driven by steam-power. The wire is charged by dipping the fingers in water, taking up a little fine (120 grade) emery and holding the fingers against the wire above the section. The wire revolves so as to cut downwards, thus carrying with it the emery taken from the fingers.

## GRINDING.

The thickness of the section which is to be ground down, in order to make it transparent, will depend on the character of the rock from which it has been cut. The more porous and fragile the rock the thicker the section should be made, an ordinary section being about as thick as a silver quarter of a dollar.

After the section has been finished on one side and cemented to a piece of plate glass, as described by Mr. Hensoldt, the work is continued as follows: The horizontal copper lap, for the first grinding, is put in place, and, after it has commenced to rotate, is charged with emery and water. This can be most conveniently done by dropping on the emery and water, either with the fingers or with a small bunch of rags at the end of a stick. A large camel's hair brush may be used for putting on the finest emery. The emery is distributed over the rotating lap by moving the section from the centre towards the periphery. The kind of emery used for this first grinding depends somewhat on the character of the rock section. If the section is composed of a hard, compact, fine-grained rock, the first emery used may be quite coarse; the coarser the emery the more rapid will be the grinding-down. For rough, quick work, Nos. 80 to 100 emery can be used until the section becomes quite thin; then, while still using the same lap, substituting the finest corn emery (next coarsest to flour emery), and continuing the grinding until the section becomes quite translucent. The lap must now be changed, and the grinding finished with the finest emery dust.

Too great care cannot be given to cleanliness while doing this

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sort of work. It is well to use one special lap for the final polishing with the emery dust, and, before putting the lap in place, all traces of the coarser grades of emery must be removed from the tray. A single grain of the coarse emery getting on the lap or the section during the final grinding, will often spoil the whole work by making a bad scratch. In grinding down the section, great care must be taken to see that the grinding surface is kept plane and parallel to the surface cemented to the glass. The section is firmly pressed against the lap by means of two or three fingers, depending on its size, and great care should be taken to have uniform pressure over all parts.

The section should be examined frequently, and if it is noticed that one part is thicker than another, place the section on the lap so that the thicker part is towards the periphery, and put a little more pressure upon this part. Gutting or grooving the copper lap is prevented by moving the section from centre to periphery and back, at the same time giving to it a slight rotary motion. It is best to have the lap revolve from right to left (in the opposite way from the hands of a watch), as, holding the section on the right side of the lap, it is easier to keep it in place by a pulling motion rather than by pushing it against the motion of the lap. In the final stages of grinding and polishing great care must be exercised, as one or two turns too many of the lap will often tear away a great part of the very thin section. The section should be frequently examined, by transmitted light, under a small, handy, low-power microscope, a drop of water or oil being put on the section to render it more transparent. If the section is thick and fastened to the plate glass with a good deal of cement, it will be found convenient, after the section has been ground quite thin, to remove most of this cement from around its edges. If this is not done, it may delay the final work of grinding down. Very often it is only necessary to determine the presence or absence of some special mineral in a section. When this is the case the work can be shortened by stopping the grinding when this mineral, or minerals of a similar kind, become visible, thus avoiding the additional time required to render the more opaque minerals transparent. A good rock section, however, should be made so thin that all the transparent and translucent component minerals can be examined and studied. The last part of the final grinding and polishing can be done by the hand on a ground-glass plate, using the finest emery-

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dust or rouge and water. In this way a very thin film can be obtained, so that minerals, generally regarded as opaque, can sometimes be made to transmit light.

In the U. S. Geological Survey Laboratory, at Washington, D. C., flour emery is used for grinding, and the finest emery dust for polishing. The finer emery makes better work, although it takes more time and is much safer to use in the case of porphyritic, porous or brittle sections, as the danger of tearing away pieces of the section is avoided. In the case of a porous or decomposed rock it is well, before grinding, to boil the section in Canada balsam or other equivalent material, so as to fill all the pores and interstices, thus making the section more compact and less liable to chip away. Sometimes it may even be best, before grinding, to mount the section on its permanent glass slide, so that, when it has been ground thin enough, the cover can be put on without running any risk in transferring the section. The only objection is that the glass slide may be a little scratched by the emery.

## Mounting.

When the section is thin enough and of uniform surface it is ready to be transferred and mounted upon its permanent glass slide. The glass plate, which has held the section during the grinding, is gently heated, and as soon as the cement begins to soften, the section is very gently pushed off into a shallow cup or evaporating dish containing turpentine or alcohol. Turpentine is used in the U. S. Geological Survey Laboratory and is most convenient for general use, because common alcohol (on account of the water it contains) unites with the shellac to form a kind of white pasty substance, which is sometimes hard to remove from the section. The section should be carefully cleaned in the turpentine or alcohol bath by means of fine camel's hair brushes. A section-lifter made from a piece of broad, flat watch-spring fastened to a small, light handle, is then gently placed under the section, which is lifted out of the bath in an inclined position so as to allow the liquid to drain off. If a drop still adheres it can be removed by touching it gently with the finger.

The section is now placed in a tray, upon a piece of white, unglazed paper, so that it may thoroughly dry; after which process it is transferred to a glass slide, and its rough edges gently chipped off with a knife.

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If the section is very large, and it is desired to mount it in two pieces, it can be easily divided by holding one half tightly between two glass slides and gently bending the other half with the fingers. The fracture will take place along the edges of the glass slides.

In the Mineralogical Laboratory of Columbia College a mixture of gum damar and benzole is used for mounting, Mr. Hensoldt claiming, after years of experience, that the gum damar does not turn yellow with age, while Canada balsam may do so. Two solutions of gum damar and benzole are used. One very thin, about the consistency of water, the other quite thick, about the consistency of mucilage. Both solutions are prepared by dissolving the gum damar in benzole and filtering through a linen or silk rag. If the solution is too thin it can be thickened by placing the bottle in a warm place and allowing the excess of benzole to evaporate, or if too thick, more benzole can be added. It is convenient to keep the solutions in short glass bottles, with wide necks and glass covers instead of corks. The solutions can be applied with glass rods.

When the section is all ready for its final mounting it is carefully centred with a coarse needle on the glass slide, and a drop of the thin solution placed at the edge of the section. Capillary attraction will cause it to flow over the glass slide under the section, and while it is soft the section can be again adjusted in place. The slide is then placed in a cool, dust-proof place and allowed to stand for about twelve hours, when the cement will be set and the section held firmly in place. The upper surface of the section is then washed with a drop of benzine, and as much as may be necessary of the thick mounting solution placed upon it with a glass rod. A cover glass of the right size is gently heated and placed in position over the section. Care must be taken not to have the cover too hot, as it would cause bubbles to form in the cement. It is also best to rest one edge of the cover on the cement first, and then lower it gently so as to prevent air bubbles from being included. The cover is adjusted and then held firmly in position by means of a mounting clamp, which presses out all superfluous cement. If a few small bubbles remain near the edges they may be let alone, as they will generally work out by themselves in time. Sometimes a large bubble can be worked out by local pressure with the finger and gentle heating with a small iron rod. If the mounting is unsatisfactory the cover should be removed by

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gentle heating, the old cement washed off with a camel's-hair brush and benzole, and a fresh cover put on. After the cement has set, the clamp can be removed, and the slide should then be left for 24 hours, or longer, if necessary, until the cement is quite hard. This takes longer in hot than in cold weather.

In the United States Geological Survey Laboratory at Washington, and in most other places, Canada balsam, or balsam fir, is used for mounting. The fir can be used liquid or evaporated down to the consistency of resin. For a description of this method of mounting I will quote from *The Study of Rocks* (textbooks of science), by Mr. Rutley, p. 69: "A glass slide (those in ordinary use for microscope preparations are perhaps as good as any for size, 1 inch by 3 inches) must then be placed on the hot plate, which, however, should have been allowed to cool beforehand; a drop of ordinary fluid Canada balsam placed carefully on the middle of the slide, and the gas or lamp lighted underneath. The section should then be taken out of the turpentine by means of a needle mounted in a handle. This may be done by gently pushing the needle underneath the section and slowly raising it, when the section will usually adhere to the side of the needle. Superfluous turpentine may be removed from the section by touching its lower edge with the finger, on to which the turpentine will flow. During this short process the balsam on the slide ought to be closely watched to see that it does not get overheated. Should it boil it is useless to proceed until another slide with fresh balsam has been warmed sufficiently without boiling. The lower edge of the section should then be placed on the balsam, the upper edge being supported by the needle, and it should be allowed to subside gently on the balsam, so that no air bubbles are included. The slide must be at once removed from the hot plate, or, better still, it should be removed before laying the section upon it. The section can be gently moved about by means of a needle to induce the balsam to pass over its edges, and the needle may then be used horizontally to drag the balsam over the upper surface of the section. If this cannot be easily accomplished an additional drop of balsam may be placed on the top of the section, and the whole very slightly heated. When the section is completely covered with balsam, a thin and clean glass cover of suitable size should be taken in a pair of forceps, held for an instant over the gas or lamp flame, and be let down gradually on the section. It should be

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gently pressed on the surface to bring it close to the section and to drive out any air bubbles; a slightly rotatory motion will be found useful for the latter purpose. The slide may then have most of the superfluous balsam scraped off and be numbered or labelled by means of a writing-diamond and set aside to dry. When what remains of the superfluous balsam is found to be tolerably hard it should be removed as much as possible by a knife with a square end (if one with a point be used there is danger of dislodging the cover), and the remainder may be cleaned off with a rag dipped in turpentine, or, better still, in benzole."

The advantage of the method used at Columbia College is that the section is firmly held in place on the glass slide before the cover is placed over it, so there is no slipping or sliding of the section, and when the cover is adjusted in place the work is well finished and the section still in the centre of the slide.

### Cleaning and Finishing.

When the cement has set the superfluous part is singed by means of a small hot iron rod. Care must be taken not to use too large a rod or to have it too hot, as the cement under the cover might soften and allow the cover to slip or air bubbles to form. The singeing drives off the more volatile part of the cement, and leaves only a brittle residue, which can be easily scraped off by a knife. In some cases it may be necessary to singe and scrape twice. The final cleaning is done with a soft rag and benzole. A neat finish can be given to the work by passing the slide quickly over a gentle alcohol flame, so that the edges of the cover may come in contact with the flame. The slides are now ready to be marked, either with a diamond pencil or with pasted labels, and put away.

The shorter glass slides for mounting are now being much used in preference to the 3 inch slides. The disadvantage of the latter being that the ends are apt to get in the way if the rotating stage of the microscope is small.

The following is a list of the convenient accessories for work in a petrographical laboratory:

Section lifters made of watch springs, three sizes.

Section holder or clamp for pressing out superfluous cement.

Needle points mounted in light handles.

Easy spring forceps.



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Mounting frame for centreing section on glass slide.
Small iron rod for singeing.
Small camel's hair brushes.
Cutting pliers and forceps.
Glass stopper bottles for benzole, benzine, turpentine and wood-alcohol.
Open neck bottles, with covers, for the two mounting liquids.
One dozen knitting needles for making drying racks.
Set of wooden section trays.
Rotating mounting stand.
Small mounting microscope for testing transparency of section.
Glass rods.
Small squares and rectangles of plate glass.
Oval and square cover glasses.
Glass slides with ground edges.

Mineralogical Laboratory, Columbia College.

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## NOTES ON SAMPLING.

By HERBERT R. WOOD, M.A.

Vein and Mine Sampling.—On the methods of sampling, vein-outcrops, prospects, and mines, depend the actual value of the property, and its value as known to the public. Vein-contents, their assay-value at the surface, and at moderate or great depth, vary greatly. The character of the ore-vein will largely determine the value of the assay-return method of sampling. The changed chemical condition which sulphides of iron, copper, and lead, undergo at the surface, and frequently to considerable depth, with an increase or decrease of silver, renders sampling uncertain and not indicative of the actual value of the mine, but only in that region of the vein in which the sampling is done.

Vein-outcrops rarely assay the average value of the vein; in some instances, however, they do, and, indeed, exceed the average value of the vein at greater depth.

A Prospect, or the first sampling done on a vein, should be made from a series of pits, dug at intervals along the vein, as a

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single excavation cannot represent the average value of the ore. Such pits should be ten or twelve feet in depth, and, if the vein is much decomposed on the surface, such samples cannot be taken as any criterion of the value of the vein throughout. Surface samples cannot be regarded of any value as to the real character of the vein. It has been said that the depth of the test pits should be at least ten feet, but they may be regulated according to the nature of the ore. If the surface cappings consist of iron oxides, and carbonates of low assay-yield, a short distance may reach the ore-body in the form of sulphides, but this must be determined by the judgment of the prospecter. Gold bearing veins are frequently richer at the surface, and the gold more apt to be in the form of large agglutinations, though at the immediate outcrop the gold may be entirely removed. When the gold accompanies iron pyrites, and oxidation goes on, the ferrous sulphate formed, acting as a slight solvent of gold, removes it, or washes it out, or deposits it in nugget-like masses.

In sampling ore in which there is native silver and silver sulphides, the same care is taken to get a quantity of ore representative of the quality of the vein, holding rock and silver in constant ratio.

In sampling a mine throughout, for buying or selling purposes, it should be sampled in all the levels, and the shaft as well.

1. When the ledge is exposed in end of tunnel, sampled thus, ×.

2. When the ledge is exposed in bottom of the shaft, sampled thus, ×.

3. When the tunnel follows ledge, the vein should be sampled from wall to wall, across both roof and floor, every ten or twenty feet.

4. In the shaft, the vein should be sampled from wall to wall on both sides, every fifty feet.

These samples should be kept separate, and separately assayed, and the average of all taken; or, the samples may be combined, quartered, crushed, and assayed—the result being the value of the ore output from the whole mine.

Pay-streaks, when distinctly marked from the rest of the vein, may be separately sampled—such streaks usually constituting first-class ore, and the balance, second-class. When the ledge is decomposed on the surface, careful sampling should be made from

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wall to wall, as usual. Marked variations in ledge matter should be kept separate.

DUMP SAMPLING.—In sampling a dump, or an ore-pile, it may be done quickly by grab-sampling. The sampler may be blindfolded while he picks up from the pile the fragments of vein and ore with which his hand comes in contact. Or, the pile may be sampled by a careful selection from its surface.

Car-samples may be taken in the same way. None of these methods are as accurate as the regular methods of sampling for buying and selling purposes.

The most satisfactory method of sampling a mine is to take from five to ten tons of the ore and ship it to a mill or smelter, where the actual commercial value of the ore can be obtained. Such a car-load should be taken from all portions of the vein.

SMELTER SAMPLING—SLAGS.—In sampling slags it is better to do so while they are hot and fluid. A slender iron rod may be used, a portion of which bent at one end serves as a handle. It is thrust into the red hot slag and quickly withdrawn, and instantly placed in a bucket of water. The thin shale of slag coating the end of the rod falls into the water. Where the slag is run in pigs on the ground as from matte reverbatory furnaces, the slag must be broken before too cool, and the rod thrust into its centre. In this case the rod is far the best, but when the slag is run into pots a small iron cap with a long handle may be used, the surface of the slag in the pot being broken and the cup thrust into the molten fluid, care being taken that all the particles of matte suspended in the slag be first allowed to settle. The slag in the cup should be cooled slowly, and, on breaking present a glassy appearance. Slag may be sampled when cool, several pieces being broken off from it, but this method is more inconvenient, and is not so representative of the quality of the slag. Surface samples should not be taken as bits of coke or flux are apt to adhere.

MATTE.—In sampling matte the cup should be used, the slight crust which has formed on the pot broken and the cup thrust well in, as slag is frequently on the surface. If, however, the pot is full of matte, it is not advisable to thrust the cup to the bottom as speiss is very apt to be present. The sample is cooled by dropping it into a bucket of water. Where the matte is run into a mouldas in copper reverberatories the matte is sampled by breaking small chips from the centre and one end of the pig.

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ZINC POTS.—The following is the method of sampling the zinc pots in the desilverization process: After the final zincing and the last alloy of zinc, a rich silver-lead is skimmed from the surface of the pot; and a long-handled pair of tongs having a cavity in each tong, which when closed resembles a bullet mould, is thrust into the pot by the workman, worked back and forward until heated, then suddenly closed, drawn up and opened on a clean board or flag-stone. This is the method of sampling the bottom of the pot, two bullets usually being taken. The upper portion of the pot is sampled by quickly thrusting in and quickly withdrawing a thin short bar of steel, rounded at one end; a thin coating of lead will adhere which can be readily removed by slitting one side. These samples will vary slightly .10, .08. The lower portion of the pot usually runs a trifle higher than the surface sample, though the workman can usually tell by the nature of the last alloy removed its crystalline structure, etc., whether the silver is all taken out.

BULLION.—The bullion direct from the blast-furnaces is sampled with a punch hammer, which removes a core from each bar. These cores may be duplicated by one from the middle of the bar and one from the end.

When pure refined or test lead is manufactured, the desilverizing process is continued till the lead assays .005 or less silver to the assay ton. This requires a repetition of the zincing process, and a re-sampling after each removal of the zinc alloys. The sampling is performed in the same way however, but the assayer uses two assay tons from the top and bottom of the pot, which he first scorifies and then cupels.

These should be taken, melted down in a pot by a moderate heat in a wind furnace and the contents poured into a mould. This may be done at the close of a month's run. The bar has a piece chiselled from the end and across the middle. This is rolled out with a hand roller to a ribbon the thickness of sheet lead, and with shears, cut across into the strips, then again cut across into small squares which are mixed up. Two assay tons weighed out which are scorified and cupelled. Usually it will be found that the middle of the bar runs a trifle higher in silver than the end.

BLAST-FURNACES.—The furnaces are sampled at the lead wells, the antimonial and copper oxides brushed off the surface and a little lead poured on to a flat cold sheet of iron near.

SOFTENING FURNACES.—The softening furnace is sampled in

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much the same way, the surface cleaned and sample poured on the flagstone pavement near the furnace.

CUPELS AND SILVER FURNACES.—In sampling cupels the surface oxide is brushed away and a cup thrust in and the contents poured on a clean portion of the hearth.

In silver furnaces the bar or poker end, first cleaned, is quickly thrust into the molten silver, coated and knocked off on to the hearth. The sample should be taken from a portion of the bath on which no trace of lead oxide floats. In sampling the silver while pouring into the moulds a bucket of clean water should be at hand, into which a portion of liquid silver from the ladle is dropped at intervals. If the ladle is held high and carefully shaken the silver will be granulated. After each sample the bucket should be cleaned and refilled.

In smelter sampling—such products as the *zinc oxide* formed by driving steam into the molten lead—after the zincing process, the *flue-dust* from blast, cupel and silver furnaces, the *litharge*, *cupel bottoms*, *furnace linings*, the most of these being sampled and assayed at the close of a month's run.

The *sampling of flue-dust and zinc oxide* is done by selecting portions from the heaps and cutting these down by a riffle to a small bulk.

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## THE ASSAY OF TIN.

BY EDMUND H. MILLER, PH.B., A.M.

THE work described in this article was undertaken for the purpose of ascertaining the best methods of assaying tin ores and also to compare the results obtained by the numerous different methods on the same ore. In order to have a check on the assays it was necessary to have an accurate analysis of the ore; to be certain of which the various methods of analysis were tried and then duplicates were run on the one which seemed best, and the average of these results was taken as representing the true amount of tin in the ore. This figure was 65.62 per cent.

The assay of tin ore is in reality the assay of cassiterite, for the other minerals containing tin are too rare to be of economic importance.

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The ore was stream tin from Durango, Mexico, contained some topaz and 8.26 per cent. of oxide of iron. The ore was ground to 80-mesh, then very thoroughly mixed and sampled for analysis.

## I. The Analyses.

The first method of analysis tried was the reduction by hydrogen in a Rose crucible.* One gramme of finely ground stream tin was placed in a small porcelain crucible and heated red-hot for four hours while a current of hydrogen was introduced through the top of the crucible. The residue was treated with concentrated hydrochloric acid, transferred to a beaker, boiled, then diluted and filtered.—Residue A.

The filtrate was neutralized with ammonia and the precipitate dissolved in a little sulphuric acid, so that the solution was slightly acid, then the tin was precipitated by sulphuretted hydrogen as dark brown SnS,—the precipitation was done in the cold and was found to be complete; the precipitate was filtered and washed with a dilute solution of ammonium chloride ignited and weighed as $SnO_2$ after treatment with nitric acid.

Residue A was dried, burned and heated as before in a current of hydrogen for one hour, then treated with concentrated hydrochloric acid, diluted, filtered, etc., and saturated with sulphuretted hydrogen,—the precipitate which formed was kept separate from the first and was washed, dried, roasted and weighed.

As the amount of tin obtained by the second reduction was very considerable, a third treatment was made on the residue from the second reduction. As a result a little more tin was obtained. A fourth treatment showed that all the tin had been removed that was possible under these conditions. Results were as follows:

| | $SnO_2$. |
|---|---|
| Residue A, weight, | .4690 |
| Residue B, weight, | .1840 |
| Residue C, weight, | .0325 |
| Total percentage, | 68.55 |

Equivalent to 53.88 per cent. tin.

These results were so unsatisfactory that the method was not investigated further.

* *Crookes' Select Methods*, p. 406.

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Reduction by means of granulated zinc* and hydrochloric acid was also tried, but without success, owing possibly to the omission of a piece of platinum foil which is claimed to greatly assist in the efficiency of the reduction.

The next method was that recommended by Rose.†

One gramme of the ore was mixed with three grammes of sulphur and three grammes of carbonate of soda and fused for one hour and a half in a porcelain crucible; the mass was then treated with water when almost all dissolved to a very dark green solution; the residue consisted of sulphide of iron, silica and undecomposed stream tin. The solution was filtered and the filtrate diluted and acidified with sulphuric acid, which produced a copious yellow precipitate of stannic sulphide, $SnS_2$; this was filtered, washed with hot water, dried, roasted with ammonium carbonate and then treated with nitric acid and weighed as $SnO_2$.

The residue was treated with hydrochloric acid to remove the sulphide of iron, then burned, mixed with carbonate of soda and sulphur and re-treated; the mass was treated with water as before, and precipitate of $SnS_2$ was obtained; a third fusion gave no more tin. Results were as follows:

| | $SnO_2$. |
|---|---|
| First fusion weight, . . . . . | .7958 |
| Second fusion weight, . . . . . | .0360 |
| Total fusion weight, . . . . . | .8318 |
| Equivalent to tin, . . . . . | .6569 |

This method was next tried, using with one gramme of the ore five grammes of sulphur and five of soda; the object was to see if by increasing the amount of flux the second fusion could be avoided. The sulphide of tin was also redissolved in ammonium sulphide as it was found some sulphide of iron was dissolved by the sodium sulphide solution.

This method gave .7676 gramme of oxide of tin.

The above method (redissolving the $SnS_2$), was then tried, but with Rose's proportions of flux, having first ground the ore as fine as possible in an agate mortar. The result was .7662 gramme of oxide of tin, which seemed to check the previous method very well, but to make sure that all the tin was out of the residue, it was

* Wells, SCHOOL OF MINES QUARTERLY, xii, 295.

† *Quant. Anal.*, p. 393.

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treated again and obtaining .0716 gramme more $SnO_2$, giving a total of .8378. This result is nearly that obtained by the first trial and goes to show that all the tin in cassiterite cannot be decomposed by one fusion.

The third method tried was fusion with acid potassium fluoride; one gramme of the ore was mixed with five grammes of acid potassium fluoride and fused at a bright red heat in a platinum crucible for twenty minutes; the mass melted very readily, and the fusion was as clear as water. After cooling it was removed from the crucible and boiled with hydrochloric acid; the acid did not attack the cake easily, and some time was spent in getting it into solution; it was then filtered. Attempts were made to precipitate the tin as oxide in this filtrate by boiling with sulphuric and with nitric acid, but were unsuccessful; the filtrate was then made acid with acetic acid and the tin precipitated by sulphuretted hydrogen; the precipitate was black and contained iron; this was filtered, treated with strong ammonium sulphide and the sulphide of tin precipitated from the double sulphide solution by neutralizing with sulphuric acid; the yellow stannic sulphide so obtained was filtered, washed, dried, roasted, treated with nitric acid and weighed as oxide of tin; weight, .7970 grammes.

This method was tried again, the fusion being kept up for over one hour; the mass was partially dissolved by water, which attacked it more quickly than hydrochloric acid, then boiled with hydrochloric acid to dissolve the iron. After filtering, the solution was made alkaline with ammonia, and then acid with sulphuric and saturated with sulphuretted hydrogen; the precipitate was treated as before; weight $SnO_2$, .7688 grammes.

This method was a third time tried and the residue re-treated; this showed that all the cassiterite was not decomposed by one fusion.

The results by this method did not compare at all favorably with those from the fusion with carbonate of soda and sulphur, because it required repeated fusions to decompose the ore, involving a loss of tin on account of the volatility of the fluoride.

A modification of Rose's method,* was next tried, using carbonate of potash instead of carbonate of soda; one gramme of the ore was mixed with 3 grammes of $K_2CO_3$ and 3 grammes of sulphur and

* *Dry Assay of Tin Ores*, H. O. Hofman, *Trans. M. E.*, 1889, xviii, p. 11.

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fused for forty-five minutes in a porcelain crucible; the mass was dissolved in water and gave a yellow solution free from sulphide of iron, instead of the dark-green solution from the soda and sulphur fusion; the rest of the operation was conducted as before, the residues being ground fine in an agate mortar each time and re-treated. Results were as follows:

| | $SnO_2$. |
|---|---|
| First fusion weight, | .4751 |
| Second fusion weight, | .2555 |
| Third fusion weight, | .0923 |
| Fourth fusion weight, | .0100 |
| Total, | .8330 |
| Percentage of, 83.30 of tin, | 65.53 |

I consider this method upon the whole the most accurate and satisfactory, although it is not a rapid one.

*Comparison of Results.*

| | $SnO_2$. | Sn. |
|---|---|---|
| 1 Rose crucible hydrogen, | 68.55 | 53.88 |
| 2 $Na_2CO_3$ and S. residue re-treated, | 83.18 | 65.43 |
| 3 $Na_2CO_3$ and S. residue not re-treated, | 76.76 | 60 32 |
| 4 $Na_2CO_3$ and S. residue not re-treated, | 76.62 | 60 27 |
| 5 $Na_2CO_3$ and S. residue re-treated, | 83.78 | 65.90 |
| 6 K. H. $F_2$, | 79.70 | 62.69 |
| 7 K. H. $F_2$, | 76.88 | 60.37 |
| 8 $K_2CO_3$ and S. residue re-treated, | 83.30 | 65.53 |
| Average of 2, 5 and 8, | 83.42 | 65.62 |

## II. *a.*—Assay Methods Giving Tin Buttons.

*German Method.**—Five grammes of the ore was mixed with one gramme of very finely ground charcoal and placed in the bottom of an ordinary Hessian crucible, No. 5. Over this was placed 15 grammes of black flux substitute mixed with 1 gramme of borax (the black flux substitute is made by mixing 10 parts $NaHCO_3$ with 3 parts flour), then a cover of salt, and on this several lumps

* Last cit. Glass, *Metallurgische Probirkundst*, Leipsic, 1882, p. 412. Kerl-Batty, *Die Probirkunde*, Brunswick, 1879, p. 391.

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of charcoal. The crucibles were put in a coke crucible fire and left there one hour and twenty minutes at a good heat. The slag was clear, well fused and dark-brown; the buttons weighed 3.10 and 3.29 grammes, respectively (Nos. 1 and 2).

Doubling the above charge was then tried, but in all other respects the assay was run in the same way. Buttons weighed 6.465 and 6.250 (Nos. 3 and 4).

The next assays were made in the same way but a lower heat was used, giving a lower result. Slag was brown, well fused. Time, one hour. Weights of buttons, 5.060 and 5.370 (Nos. 5 and 6).

(No. 7.) Same charge but hotter fire; gave good button weighing 6.365, Nos. 8 and 9. These assays were made in a charcoal-lined crucible. Ten grammes of ore and 2 grammes of charcoal were mixed together and put in the bottom, then covered with a mixture of 20 grammes of black flux substitute and 1 of borax glass, then lumps of charcoal. The assays were heated as usual; they were unsuccessful, as the porous lining seemed to absorb all the slag, so that the button did not collect well.

Nos. 10 and 11 were an experiment, as 5 grammes of argol were substituted for the flour in the black flux substitute; so the charge was as follows: Ore, 10; charcoal, 2; argol, 5; soda, 20; borax glass, 1. Salt cover, charcoal. They were fused in a hot fire for three-qnarters of an hour. Weight of buttons, 4.40 and 3.25 grammes.

Nos. 12 and 13 were run in charcoal-lined crucibles with the following charges: Ore, 5 grammes; B. F. S., 15 grammes; borax glass, 1 gramme; charcoal, 1 gramme; salt cover, lump charcoal. Time, one hour; good reduction, but buttons failed to collect well. Results practically same as Nos. 8 and 9.

Nos. 14 and 15. Charge same as 3 and 4 but fire very hot (white heat). Time, one hour. Buttons, 6.422 and 6.683.

This shows that it is possible to reduce iron by the German method if the charges are heated to a white heat.

Nos. 16 and 17. Same as 15 and 16, but moderate fire. Buttons, 6.281 and 6.278.

I then tried the German method in the muffle furnace using flat bottomed crucibles. Charge same as 1 and 2. Time, 45 minutes. White heat. Weights of buttons, 3.270 and 2.890. Nos. 18 and 19.

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*Comparison of Results.*

| Assay. No. | Time. Minutes. | Fire. | Slag. | Percentage. |
|---|---|---|---|---|
| 1, | 80 | Hot. | Brown. | 62.00 |
| 2, | " | " | " | 65.80 |
| 3, | " | " | " | 64.65 |
| 4, | " | " | " | 62.50 |
| 7, | 60 | " | " | 63.65 |
| 14, | " | White heat. | " | 64.22 |
| 15, | " | " | " | 66.83 |
| 16, | " | Moderate. | " | 62.81 |
| 17, | " | " | " | 62 78 |
| Average, | | | | 63.92 |

I believe this to be one of the best methods of determining tin in a high grade ore; to be run successfully a long time (*i.e.*, 1 hour) and a hot fire, between a bright red and a white heat, but not as hot as a white heat, are necessary. I think good results may be obtained in the muffle by this method.

*Cyanide Method.**—The first three assays by this method were made with a very poor quality of cyanide, such as is used for amalgamation. Charge was: Ore, 10 grammes; 5 grammes cyanide put in bottom of crucible; 25 grammes cyanide mixed with ore and placed on top, then a cover of 5 grammes of cyanide and a cover of salt. The charges were heated up slowly and left in a moderate fire for 20 minutes after fusion. Weights of buttons were as follows: No. 20, 5.78; No. 21, 5.840; No. 22, 5.675.

Five assays were next made using different amounts of cyanide and mixing it all with the ore. The object was to ascertain what quantity of cyanide it was necessary to use and also to see whether the layer of cyanide in the bottom and on top was advantageous.

In each case 10 grammes of the ore was used and the charge heated in a good fire for 25 minutes.

| No. | Cyanide. Grammes. | Weight Button. | Percentage. |
|---|---|---|---|
| 23, | 10 | 1.744 | 17.44 |
| 24, | 20 | 4.170 | 41.70 |
| 25, | 30 | 4.941 | 49.41 |
| 26, | 40 | 5.073 | 50.73 |
| 27, | 50 | 5.195 | 51.95 |

* *Dry Assay of Tin Ores*, p. 22, Hofman. Ricketts, *Notes on Assaying*, p. 86. Mitchel's, *Assaying*, p. 409. Beringer, *Assaying*, p. 234. *Die Probirkunde*, 1879, p. 391.

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These assays show that up to 50 grammes the amount reduced increases with the amount of cyanide used, and also that the layers of cyanide top and bottom are necessary. Nos. 28 and 29. Ore, 10 grammes; 5 grammes KCy in bottom, then 30 grammes mixed with ore, then 5 grammes KCy, then salt cover—ordinary unlined Hessian crucibles were used—as in previous assays. Charges were heated for 1 hour in a hot fire. The cyanide used was of a better quality than that employed in the first assays. Slag was dark green and well fused. Weights of buttons were 6.295 and 6.860. Nos. 30 and 31 were run as above except that chalk-lined crucibles were used. The slags were light green, porous and pasty. Buttons weighed 5.300 and 6.030.

Nos. 32 and 33 were run with same charge in a hot fire for 45 minutes. Slag was green. Buttons weighed 6.683 and 6.442.

Nos. 34 and 35 same as above, except in chalk-lined crucibles. No. 34 slag porous. Result low. No. 35 slag green. Button weighed 6.842.

No. 36 was run in an unlined crucible with the usual charge, but with chemically pure cyanide (98 per cent. KCy) in as hot a fire as possible. Slag was white. Button weighed 7.089.

No. 37 same as No. 36, but in chalk-lined crucible. Time of both 45 minutes. Weight button, 7.190.

Nos. 38 and 39 same charge, but low heat. No. 38 naked crucible. Weight button, 6.870. No. 39 chalk-lined crucible, 6.315.

Nos. 40, 41 and 42 same charge, except no salt cover, ordinary cyanide being used. Moderate fire; time 30 minutes. Slag gray. Weights, No. 40, 6.193; No. 41, 6.015; No. 42, 6.175. Buttons were well formed, bright and fairly soft.

Nos. 43, 44 and 45 same as previous, but pure cyanide was used. No. 43, 6.938; No. 44, 6.896; No. 45, 6.812. Buttons were dull.

The next assays were run to test the merits of the salt cover; the usual charge was used (ordinary cyanide). Nos. 46 and 47 had salt covers. Nos. 48 and 49 had not. 46 and 48 were in one fire and 47 and 49 in another, so the conditions were the same in the case of those with and without salt covers. Weights, No. 46, 6.362; No. 47, 6.590; No. 48, 5.970; No. 49, 5.920.

This seems to me to be sufficient to show the advisability of using a cover of salt.

I next tried some assays to see if a mixture of black flux sub-

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stitute and cyanide would give satisfactory results, and found that it would not.

No. 50, ore, 10 grammes, KCy, 5 grammes, in bottom, then KCy, 20 grammes and B. F. S., 10 grammes, mixed with ore, then KCy, 5 grammes, salt cover. Moderate fire, 30 minutes. Slag white. Button weighed 6.005.

No. 51 same as No. 50, except KCy 15 grammes, B. F. S. 15 grammes, mixed with ore. Weight of button, 6.045.

No. 52 same as 50, encept KCy 10 grammes, B. F. S. 20 grammes, with ore. Weight of button 5.955.

No. 53 same as 50, but time 45 minutes in a fairly hot fire. Weight of button 6.160.

No. 54 same as 53, except KCy 10, B. F. S. 20. Weight of button 5.793.

No. 55 same as 53, except B. F. S. 30 grammes. Weight of button 5.277.

From the assays by the cyanide method it seems that: first chalk-lined crucibles are objectionable because they render the fusion pasty at a low temperature giving a porous slag, while, if the heat is raised so as to fuse them, iron is reduced which renders the results too high; second, chemically pure cyanide will reduce iron at a lower temperature than the ordinary cyanide; third, a salt, cover is necessary; fourth, the layer of cyanide on the bottom and top of the charge is a decided advantage.

I also tried running cyanides in the muffle; the following charge being used. Ore, 5 grammes, KCy, 5 grammes on the bottom, then 25 grammes mixed with the ore then cover of cyanide, then salt and finally lumps of charcoal. They were kept in a hot fire for twenty minutes, the buttons were good.

| No. | Weight button. | Per cent. |
|---|---|---|
| 56, | 3.218 | 64.36 |
| 57, | 3.443 | 68.86 |

*Cryolite Method.*—Was tried as follows: Ore, 10 grammes, cryolite, 10 grammes, charcoal, 2 grammes, mixed together and put in naked crucible, and covered with salt and charcoal; heated in crucible fire; result no buttons, and no apparent reduction. (No. 58 and 59).

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## II. *b*.—Assay Methods Giving Alloys from Whose Weight the Amount of Tin can be Calculated.

*Bronze Buttons.**—First method. Oxide of copper and black flux substitute. No. 60 and 61: Ore, 10 grammes, oxide of copper (CuO), 10 grammes, black flux substitute, 40 grammes, borax glass, 1 gramme, were mixed together and put in an unlined Hessian crucible, and then a cover of salt added; the crucible was placed in a hot fire and the charge fused for one hour; the slag was dull green and well fused, buttons weighed 13.13 and 12.82 grammes; subtracting the amount of copper in 10 grammes of oxide of copper 7.97 gives the weight of tin 5.260 and 4.850. No. 62 and 63, same as above except crucibles were lined with chalk: weight of tin in buttons 5.600 and 5.250. No. 64 and 65: Ore, 10 grammes B. F. S., 10 grammes mixed and put in a charcoal lined crucible, covered with lumps of charcoal; crucibles were heated as before one hour in a hot fire; there was very little slag as most was absorbed by the lining. Weights of buttons, 14.02 and 13.85, equivalent to 60.50 and 58.80 per cent. of tin.

These results corroborate those obtained by cyanide and black flux substitute, and show that black flux substitute is not a proper reducing agent for cassiterite under any conditions.

*Oxide of Copper and Cyanide of Potassium.*—No. 66 and 67: 5 grammes of cyanide was placed in the bottom of an ordinary No. 5 Hessian crucible, then 30 grammes of cyanide was mixed with 10 grammes of the ore and placed on top, then a cover of cyanide (no salt). Charge was heated for one hour in a fairly hot fire; the slag was stony and gray, buttons were bright and well formed, weighed No. 66, 13.7660, No. 67, 13.480 equivalent to tin, 5.796 and 5.490 (subtracting 7.97). No. 68 and 69 same as above but run in chalk lined crucibles; slag was porous and buttons were not well shaped; weighed 13.72 and 13.89; tin 5.750 and 5.920.

Two assays were run in unlined crucibles with same charge, and salt cover, and with them a blank assay to determine the real amount of copper reduced, 70, 71, 72.

| No. | Weight button. | | Per cent. |
|---|---|---|---|
| 70, . . . . . | 13.8660 | 7.3960 | 6.470 |
| 71, . . . . . | 13.7150 | 7.3960 | 6.3190 |

7.3960 is the weight of copper button from the blank assay; this

* Hofman, p. 37. Winkler, *Berg und Huttenmännische Zeitung*, 1864, p. 17. Mitchel, p. 411.

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is very much below the theoretical amount of copper present, 7.97, and accounts for the low results in assays 66, 69; subtracting the weight of copper obtained from the blank from the weight of these bronze buttons, I get as follows: No. 66, 6.370, No. 67, 60.90, No. 68, 6.330, No. 69, 6.500.

In this method the disadvantage of the chalk lining is not in the weight of the buttons, but in the porous and pasty condition of the slag and in the irregular form of the buttons.

Had a blank assay been run with the black flux substitute assays better results would have undoubtedly been obtained, but the weights were so low that the method did not seem to merit further investigation.

### II. *c.*—Assay Methods Giving an Alloy to be Treated by Wet Methods.

*Copper Oxide and Cyanide.*—Two grammes of the ore was mixed with 10 grammes of cyanide, and placed in a small Hessian crucible on a layer of cyanide, and then covered with a second layer as usual, then salt cover, and heated in a hot fire three quarters of an hour.

Three assays were run in this way and the results averaged. No. 72, 73, and 74, the buttons were then treated with nitric acid and the oxide of tin weighed. The percentage of $SnO_2$ was 81.26 equivalent to 63.92 of tin.

| | Grammes. |
|---|---|
| Average weight of bronze buttons, . . . . . | 4.857 |
| Average weight of tin subtracting theoretical amount of Cu in 5 grammes CuO, . . . . . | .872 |
| Average weight of tin subtracting Cu as found blank assay, . | 1.159 |
| Average weight of tin in buttons as calculated from weight of $SnO_2$, . . . . . | 1.2784 |

This method of using copper as a collecting agent for the tin is recommended for low grade ores as it prevents the loss of small particles of tin in the slag.

From the foregoing experiments there seems to be four methods of assaying cassiterite which give sufficiently accurate results for practical work: the German method; cyanide; oxide of copper and cyanide when blank assay is run; oxide of copper and cyanide when button is treated with nitric acid and the oxide of tin weighed.

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Assays of tin should always be run in duplicate and the average, not the highest, taken.

In the German method an hour in a fire almost at a white heat gives the best results.

*Cyanide Method.*—The following charge is the best. KCy 5 grammes in bottom of crucible, then 30 grammes mixed with the ore then cover of 5 grammes more then salt cover; use an unlined crucible and heat at a red-heat (not a bright red), for twenty to twenty-five minutes; the results obtained using this charge were as follows:

| No. | | Per cent. |
|---|---|---|
| 32 | Ordinary KCy, hot fire 45 minutes, salt cover, . . | 66.83 |
| 33 | | 64.42 |
| 46 | Ordinary KCy, low heat 30 minutes, salt cover, . . | 63.62 |
| 47 | | 65.90 |
| Average, . . . . . | | 65.19 |

Oxide of copper and cyanide: Use same same charge as in cyanide method adding 10 grammes of black oxide of copper; heat in a hot fire for three quarters of an hour; with every set of assays run one with same charge, leaving out the ore and subtract the weight of the copper button from the weights of the bronze ones. Results by this method:

| No. | Per cent. |
|---|---|
| 70, . . . . . | 64.70 |
| 71, . . . . . | 63.19 |
| Average, . . . . . | 63 95 |

In the method where the bronze button is dissolved in nitric acid it is not advisable to get too large a button on account of the time taken in dissolving it; I would recommend taking such amounts of ore and oxide of copper as to give a button of about three grammes, of which over two grammes should be copper.

There are several other methods of assaying tin in use, and many more to be found by consulting the literature on the subject, but they all seemed less feasible than the ones described.

One very important point in connection with the assay of tin ores is the concentration of a large sample down to a small one containing the tin for assay; this may be done in a pan, or by coarse jigging. The high specific gravity of cassiterite renders this comparatively easy.



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# ABSTRACTS.

## ANALYTICAL CHEMISTRY, BY E. WALLER, PH.D.

*Composition of Glass Suited for Chemical Apparatus.* Weber and Sauer (*Berichte*, xxv., 70). Flasks constructed of glasses of different composition were tested by boiling in them water, 25 per cent. $H_2SO_4$, 12 per cent. HCl, 10 per cent. ammonia, 2 per cent. $Na_2HPO_4$, and 2 per cent. $Na_2CO_3$, and then determining the amount of loss sustained. The water was caused to act for five hours, the other reagents for three hours each. The glass least affected by the reagents had the composition $6SiO_2 : 1CaO : 1.3–1.5$ alkali. It is preferable to have $Na_2O$ predominate over the $K_2O$.

*Testing Ammonia Solution.* Hertkorn (*Chem. Zeit.*, xv., 1493) finds that ammonia solution may contain carbamate. If an equal bulk of lime-water is added only a trifling turbidity may be produced. (Test of the German Pharmacopœia for carbonate.) Carbamate may, however, be present, and fail to show its presence until the mixture is heated.

*Impurities in Platinic Chloride.* Holleman (*Chem. Zeit.*, xvi., 35). The presence of sulphuric acid is not detected by the usual tests—clear solution with absolute alcohol, and the residue after ignition yielding nothing soluble in $HNO_3$. A sample containing $H_2SO_4$ was found to give unsatisfactory results in the determination of potassium.

*Standardizing Alkalimetric Solutions.* Weld (*J. Anal. and App. Chem.*, vi., 191) has tested standardizing HCl gravimetrically and volumetrically with $AgNO_3$, exactly neutralizing with ammonia and distilling with NaOH, neutralizing with $NaHCO_3$, etc. His conclusions are: 1, that the gravimetric method gives too low results; 2, that the distillation of an ammonia salt with NaOH gives too high results; and 3, that the true value of standard solutions may be obtained very closely with either soda, potassium, tetroxalate, oxalic acid, or sodium bicarbonate.

Potassium tetroxalate was found to possess many disadvantages.

*Potassium Determination.* Jean and Trillat (*Bull. Soc. Chim.* [3] vii., 228). Dissolving the $K_2PtCl_6$ in boiling water and precipitating Pt by boiling with $NaCHO_2$ has the disadvantage of giving very finely divided Pt, which may run through the filter or adhere to the beaker. The use of formic aldehyde gives a precipitate not possessing these objectionable features.

*Potassium Estimation.* Wense (*Zts. f. Angew. Chem.*, 1891, 69). The perchlorate method has fallen into disuse on account of the solubility of the potassium perchlorate in water or alcohol. The author finds that it

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is practically insoluble in a mixture of alcohol and ether (2 : 1), and also in alcohol containing 0.2 per cent. of perchloric acid, and that by use of such alcohol accurate estimations can be made.

*Separation of Strontium and Calcium.* Browning (*Am. J. Sci.*, xliii.) applies the use of amyl alcohol on the nitrates in a similar manner to Gooch's method for the separation of LiCl from KCl and NaCl. $Ca(NO_3)_2$ is quite soluble in anhydrous amyl alcohol, whereas $Sr(NO_3)_2$ is scarcely soluble. Evaporate the aqueous solution containing the mixed nitrates (0.2 gramme of each) nearly to dryness, or, if dried, redissolve in very little water, add about 30 c.c. amyl alcohol, boil out the water, filter, wash with anhydrous amyl alcohol, dry at 150° and weigh $Sr(NO_3)_2$. Add 0.001 gramme to the calculated weight of SrO for every 25 c.c. of amyl alcohol left at the end of the boiling.

*Titration of Iron.* Moraht (*Zts. f. Anorg. Chem.*, i., part 3). The standard solution is one of potassium ferrocyanide. The precipitate is $Fe_7Cy_{18}$. The indicator is KCNS. In order that the end-reaction may be readily detected, ether is added, in which the ferric sulphocyanate is soluble. The operation is conducted in a flask fitted with a ground stopper; about 50 c.c. of ether is added, and the flask closed and vigorously shaken after each addition of the standard solution, until the ether becomes colorless. A preliminary rough titration, followed by a close titration, on separate portions of the solution, are usually necessary.

*Iron in Bone-Black.* Terne (*J. Anal. and App. Chem.*, vi., 211) finds that bone-black has a tendency to remove iron from solutions rather than to give it up to them. The most of the iron can be removed by passing a magnet through the ground black spread on a sheet of paper. Results obtained in this way are always in excess of the truth, from adherence of C, etc., but the method is useful.

For the chemical determination, incineration of the black is necessary, since the organic matter of fresh black may reduce some permanganate, and be reckoned as iron.

*Copper and Nickel in Ores, etc.* Browne (*Jour. Anal. and App. Chem.*, vi., 181) gives the method pursued in the laboratory of the Canadian Copper Company at Sudbury, Ont.

For ores, etc., containing about 10 per cent. of combined metals, take 1 gramme. For mattes containing 40 or 50 per cent. metal, 0.5 gramme. For richer samples, 0.25 gramme.

Dissolve in No. 1 beaker with 10 c.c. strong $HNO_3$ and 3 c.c. HCl, evaporate slowly to dryness, dissolve in $H_2O$, add a few drops $H_2SO_4$, filter, add a drop of strong $HNO_3$, and precipitate Cu by the battery (4 gravity cells suffice for six solutions); leave over night.

Oxidize the liquid decanted from the Cu with $HNO_3$ and precipitate twice with ammonia. Dissolve the second precipitate in HCl, neutralize completely with $Na_2CO_3$, add 10 c.c. $HC_2H_3O_2$ and a teaspoonful of $NaC_2H_3O_2$. Just bring to a boil, stir, let settle, filter, and wash as usual. Concentrate the filtrate.

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Unite all the filtrates in a No. 6 beaker. Neutralize with HCl, make faintly ammoniacal, heat to boiling, and pass $H_2S$ for five minutes. Let settle, keeping the solution hot. Filter rapidly through a large filter, 12.5 c.m. Wash two or three times with hot water.

Dry the precipitates, incinerate in porcelain crucibles, dissolve in a little water with a few drops $HNO_3$, evaporate to dryness slowly and then dissolve in a little $H_2SO_4$, render strongly ammoniacal and precipitate the Ni electrolytically. Six solutions require fully nine Grove cells. Leave over night.

Some analysts in that section use the English cyanide titration for Ni. KCy is run into a faintly acid HCl solution until $NiCy_2$ is redissolved. The author does not find this satisfactory.

*Quantitative Separation of Members of the $H_2S$ Group in a Current of Bromine.* Jannasch and Etz (*Berichte*, xxv., 736). Analysis of Wood's metal. Dissolving in aqua regia, and finally obtaining the metals as sulphides, was found to be less convenient than fusing with S in a stream of $CO_2$. On heating gently the mixed sulphides in a boat enclosed in a tube through which was passed Br vapors, $SnBr_4$ and $BiBr_3$ were volatilized, while $PbBr_2$ and $CdBr_2$ remained behind. From the solution of the non-volatiles bromides Pb was separated as $PbSO_4$, and then Cd as $CdCO_3$. Sn and Bi were separated by evaporating with strong $HNO_3$ and igniting strongly the mixed oxides. Then, heating for some time with dilute $HNO_3$, extracted all Bi, leaving pure $SnO_2$. In the solution Bi was precipitated by $(NH_4)_2CO_3$. The precipitate is liable to contain $SiO_2$ from the crucible, which should be separated and deducted.

*Analysis of Galena.* Jannasch and others (*Journ. f. prakt. Chem.*, xlv., 101 *et seq.*). *Decomposition.* Various methods were tried, many of which were too elaborate to be convenient. Oxidation with $HNO_3$ and Br or heating in a current of Br vapor were found satisfactory.

*Separating Pb.* 1. One method used was extracting the evaporated residue from the decomposition by NaOH lye, and precipitating $PbO_2$ from this solution by Br water. The precipitate was washed with NaCl solution, and then converted to sulphate for weighing. 2. By another method $PbSO_4$ was dissolved from the gangue (after decomposing) with $NH_4C_2H_3O_2$, and $PbO_2$ precipitated from the solution by ammonia and $H_2O_2$ in the cold. 3. The lead also was separated from the gangue by extraction with Cl water and $HNO_3$, being finally separated as $PbSO_4$ from the solution.

*Separation of Antimony, Arsenic and Tin.* Clark (*J. Lond. Chem. Soc.*, lxi., 434). The mixed sulphides are treated in a distilling flask with HCl (gr. 1.10) and an excess of ferric chloride solution with strong HCl (about three parts Fe to every one part of mixed sulphides) is added. After distilling off about three-fourths of the liquid, more HCl is added and the distillation repeated. A third distillation usually suffices to remove all the As, which may be separated from the distillate by $H_2S$, dissolved in ammonia and eventually precipitated and weighed as $As_2S_3$.

The solution in the flask is filtered hot, mixed with hot solution of oxalic acid (about twenty parts $H_2C_2O_4$ to one of mixed sulphides), and $H_2S$

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passed through it until it is cold. Do not heat after the addition of $H_2C_2O_4$, also do not allow it to stand very long before filtering. Filter, wash with water, then with alcohol, then with $CS_2$, and again with alcohol keeping the filtrate and aqueous washings separate from the alcohol and $CS_2$. Dry the $Sb_2S_3$ at 130° and weigh. Heating to 200° C. causes loss by oxidation.

In the filtrate destroy $H_2C_2O_4$ by adding permanganate in excess, then a little $FeSO_4$ to dissolve the $MnO_2$, etc., and precipitate Sn by $H_2S$. Ignite to $SnO_2$ and weigh.

Gooch and Danner (*Am. J. Sci.* [3], lxii., 308) separate As and Sb by the distillation process, but reduce beforehand by HI in order to titrate the Sb in the undistilled portion, without interference from Fe salts. In their process the solution (which should not contain over 1 gm. of the oxides) is mixed with excess of KI made up to 100 c.c. with HCl, and HCl gas passed in during distillation. After distilling off fully 50 c.c., a slight excess of $SO_2$ followed by cautious addition of I (to destroy excess) is added. Then 1 gm. tartaric acid is added, the solution neutralized with NaOH, $NaHCO_3$ added and Sb is titrated with tenth normal iodine.

*Hydroxylamine Hydrochloride as a Reagent for Gold and Silver.* Lanier (*Monatsh.*, 1891, xii., 639). In a solution alkaline with KOH the reagent precipitates metallic silver quantitatively. The presence of citric and other organic acids does not interfere.

The reagent precipitates gold from its solutions without the addition of KOH, more readily on warming. The reaction does not occur in presence of KCy, but does take place in presence of $Na_2S_2O_3$.

*Molybdenum and Tungsten.* Traube (*Abst. in Berichte*, xxv., 47). Scheelite was found to contain $MoO_3$ invariably (from traces up to 8 per cent.). The so-called "pure" tungstic acid of commerce contains usually 10 per cent. of $MoO_3$. The method of separation used was that of H. Rose—precipitation by $H_2S$ in a tartaric acid solution, which however leaves much to be desired on the score of completeness.

*Reaction of Cerous Oxide.* Plugge (*Arch. d. Pharm.*, ccxxix., 558). Render the suspected solution just alkaline with NaOH, evaporate to dryness on a slab of porcelain, and mix the residue with two or three drops of strong $H_2SO_4$ containing one part of strychnine in 1000 parts of the acid. If cerium is present a bright blue color soon altering to a permanent cherry-red color is seen. 0.0001 gm. Ce gives the reaction decidedly. 0.00001 gm. Ce gives a perceptible blue violet color, which is, however, fugitive. The reaction is not obtained in presence of certain sulphides.

*Determining Iodine, Bromine and Chlorine.* Schierholz (*Monatsh. f. Chem.*, xiii., 1). *Indirect method.*—Divide the solution in halves. In one half titrate with standard $AgNO_3 = a$, filter and weigh the precipitate *b*. Then add to the other half a few gms. KBr and then run in as much $AgNO_3$ as was used in *a*. Filter and weigh the precipitate *c* which consists of AgI and AgBr only. From the values of *a*, *b* and *c* the amounts of the halogens present may be calculated.

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*Direct methods.*—In the presence of much Cl and little Br, I : Br : Cl = 1 : 6 or 7 : 1000 the addition of very little $AgNO_3$ will precipitate only AgI, the bromide and chloride being soluble in a large excess of alkaline chloride.

The Br may be separated by distillation with $K_2Mn_2O_8$ and $Al_2(SO_4)_3$.

*Separation of Chlorine, Bromine and Iodine.* Jannasch and Aschoff (*Zts. f. anorg. Chem.*, I. part 2). Dilute the solution (containing the equivalent of about 0.3 gm. each of NaCl, KBr and KI) to 750 c.c. add 5 c.c. dilute $H_2SO_4$ and then 1 gm. $NaNO_3$ in solution, and cork the flask immediately. I is at once set free, and is driven over (by passing steam) into a mixture of NaOH and $H_2O_2$ in a deep cylinder. A second cylinder containing also the same mixture is desirable as a guard. These cylinders should be kept cold. The I will be driven over in the course of about fourteen minutes (shown by the color). The steam is kept passing until the delivery tubes have been rinsed off. The contents of the cylinders are evaporated after addition of 50 c.c. $H_2O_2$ solution. After some hours $AgNO_3$ is added with stirring until the dark color of the precipitate no longer changes to yellow. Then acidify with $HNO_3$, heat some time and filter and wash hot.

To separate the Br, render the solution containing it alkaline, concentrate to 50 c.c., cool, mix with dilute $HC_2H_3O_2$, add 1 to 1.5 gm. $K_2Mn_2O_8$ and distill the Br by steam into an alkaline solution, the solution being treated as in the case of I.

In the solution which still contains the Cl the excess of $K_2Mn_2O_8$ is reduced with alcohol and alkali filtered, and the determination made as usual.

*Fluorine Estimation.* Carnot (*C. Rend.*, cxiv., 750) recommends passing $SiF_4$ into solution of pure KF (10 per cent,) and separating and weighing $K_2SiF_6$.

The generating flask has a capacity of about 150 c.c. and is so connected that through the liquid therein may be passed a slow current of *dry* air or $CO_2$ during the operation.

The exit tube from the generating flask should have on it a bulb to receive $H_2SO_4$ possibly carried over with the $SiF_4$, and leads into another flask containing a layer of mercury, on top of which is placed 20 c.c. of the KFl solution. The end of the tube should dip below the surface of the mercury. If the material contain chlorides, a tube containing pumice soaked with $CuSO_4$ and then dehydrated must be inserted in the train.

The quantity of material taken should contain about 0.100 gm. Fl. It should be mixed with finely ground quartz in such proportion that at least 10 parts $SiO_2$ are present to every 1 part Fl. The absolute tightness and dryness of the generating flask and connecting tubes must be first insured. Then place the mixture in the flask, pour in 40 c.c. conc. $H_2SO_4$ and heat to about 160°—not over. The operation is complete in 1½ to 2 hours. Then detach the receiving flask and rinse the solution in a convenient vessel. The combined solution and washings should not exceed 100 c.c. Add an equal bulk of alcohol (90 per cent.). Allow to stand, filter on a tared filter and wash with diluted al-

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cohol until $BaCl_2$ gives no turbidity in the washings. Dry at 100° and weigh.

*Analysis of Natural Phosphates.* Chatard (*Am. Inst. Min. Eng., Baltimore Meeting,* February, 1892) gives his methods, which are not claimed to be original. *Moisture.*—Dry 2 gms. at 105° C. for three hours. *Combined water and organic matter.*—The residue from the last is gradually heated to full redness, and then ignited over a blast lamp. Repeat until the weight is constant. From the loss deduct $CO_2$ (determined elsewhere) and reckon the rest as combined water and organic. This is not absolutely accurate if Fl is present. *Carbonic acid.*—Use the distillation method described by Gooch.—(*Bullet. 47 U S. Geol. Survey.*

*Insoluble matter, etc.* Treat 5 gms. with 25 c.c. $HNO_3$ (Gr. 1.2) and 12.5 c.c. HCl (Gr. 1.12) in a covered beaker on a water bath for 30 minutes, stirring from time to time. Dilute with cold water, stir, and allow to settle. Filter into a 500 c.c. flask, wash with *cold* water, dry and ignite (finishing with blast lamp). The presence of Fl here also causes incorrect results, but is essentially correct for commercial purposes. Test the residue for $P_2O_5$. Dilute to the 500 c.c. mark with cold water and mix well.

*Phosphoric acid.* Evaporate two portions of 50 c.c. each (= 0.5 gm.) until HCl is expelled, add to each 150 c.c. molybdate solution. Stir in, heat thoroughly on water bath, and then allow them to stand until quite cold (at least 3 hours). Filter and wash with cold 20 per cent. $NH_4NO_3$ solution containing one-thirtieth of its volume of $HNO_3$. Test filtrate for any further precipitate. Rinse the precipitate back into the beaker and dissolve in dilute ammonia with the aid of a gentle heat. Filter through the same funnel into a clean beaker, washing with ammonia (1 : 4). Bring to a boil and add Mg solution drop by drop with stirring, until the reagent shows no further precipitation. When this is the case, and the precipitate is all crystalline, chill by placing in cold water. When cold test with more Mg solution. Then add one-third its volume of ammonia, let stand three hours and filter. For filtering, asbestos felt in a Gooch crucible is preferred. Moisten with a little $NH_4NO_3$ just before drying and igniting. If paper is used it is preferable to dissolve through the filter with $HNO_3$ into a weighed dish, evaporate dry and ignite.

*Lime* (Jones' method, *vide* QUARTERLY).—Evaporate 100 c.c. (= 1 gm.) to about 50 c.c.—add 10 c.c. diluted $H_2SO_4$ (1 : 5). Evaporate until a considerable crop of $CaSO_4$ crystals have formed. Cool; when cold, add gradually 150 c.c. of 95 per cent. alcohol with stirring; let stand 3 hours, stirring from time to time. Filter into a distillation flask by the aid of a pump, washing with 95 per cent. alcohol. Ignite and weigh $CaSO_4$.

*Alumnia and Ferric Oxide.*—Distil off the alcohol from the filtrate just obtained, which is in this way recovered. Rinse the contents of the flask into a platinum dish, evaporate low. Destroy organic matter by adding a little $NaNO_3$ and fusing cautiously. Dissolve in hot water acidulated with $HNO_3$, make distinctly alkaline with ammonia, neutralize with acetic acid, boil, settle and filter. Wash with hot water, finally with dilute $NH_4NO_3$ solution, dry, ignite and weigh. The determina-

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tions are thus far made in pairs. In one portion determine $P_2O_5$ by fusing with $Na_2CO_3$, dissolving in $HNO_3$, precipitating with molybdate, etc. In the other fuse with $Na_2CO_3$, dissolve in $H_2SO_4$, reduce and titrate Fe.

*Magnesia.*—Evaporate the filtrate from the above to small bulk, render strongly ammoniacal, cool, and allow to stand and deposit *crystalline* $MgNH_4PO_4$.

*Fluorine* (Berzelius method).—Mix thoroughly 2 gms. of the sample with 4 gms. precipitated silica and 12 gms. $Na_2CO_3$ and fuse. Cool rapidly, cover with hot water and digest on the water bath until completely disintegrated. Filter, nearly neutralize the filtrate with $HNO_3$ (using methyl orange as indicator), add some pure $NaHCO_3$ and heat up on the water bath. When warm, remove from the bath, stir, let stand 2 or 3 hours, and filter, washing with cold water. Concentrate to about 250 c.c., nearly neutralize as before; add $Na_2CO_3$ and precipitate the $P_2O_5$ by addition of $AgNO_3$. Filter and wash with hot water. Remove excess of $AgNO_3$ by addition of NaCl. Add some $NaHCO_3$ to the filtrate, evaporate to the crystallizing point, cool, dilute with cold water, add more $NaHCO_3$ and let stand for the separation of silica. Filter, nearly neutralize the filter as before; add a little $Na_2CO_3$; heat to boiling and add an excess of $CaCl_2$. Boil for a few minutes, filter off the mixed $CaF_2$ and $CaCO_3$ and wash with hot water. Rinse the precipitate into a small platinum dish. Burn the paper and add the ash to the precipitate. Dry and ignite the whole. After cooling, add excess of dilute acetic acid and evaporate to dryness. Extract the calcium acetate with hot water, filter, ignite carefully and weigh $CaFl_2$. Add to this $H_2SO_4$, heat and weigh again $CaSO_4$. The two weights should agree closely (by calculation), though the figure reported for Fl should be calculated from the weight of the final $CaSO_4$, since some silica is always precipitated with the $CaF_2$.

The modifications are chiefly the use of $NaHCO_3$ to separate silica and the keeping the solutions dilute; details not readily obtained by the use of ammonium carbonate.

*Reverted Phosphoric Acid.* Gibson (*Bulletin No. 28, U. S. Dept. Agric.*, p. 166) found that unless the ammonium citrate solution is perceptibly alkaline the proportion of phosphate dissolved from a fertilizer is liable to be very different from that in the case where the citrate is barely neutral or faintly acid. His preference is for Joulie's alkaline solution, as giving more constant results. Huston (*Bullet. 31*, p. 101) finds that the time of digestion has a greater influence. The reverted phosphate appears to dissolve tolerably rapidly during four hours, is nearly complete at the end of five hours, but continues much longer.

*Uranium Titration of Phosphoric Acid.* Coleman and Granger (*J. S. C. Ind.*, xi., 328). For standardizing it is found that (1) the uranium solution must be standardized by means of calcium phosphate; (2) the percentage value of calcium phosphate used for standardization must be estimated gravimetrically.

*Volumetric for Phosphoric Acid.* Spica (*Gazz. Chem. Ital.*, xxii., 117). Titration with standard solution of potassium iron alum, in a neutral

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solution, using salicylic acid as indicator. For Thomas slags, etc., wet down the pulverized material with $H_2SO_4$, heat to expel the excess, take up with absolute alcohol, filter, boil off the alcohol, add a few drops of phenolphthalein, neutralize exactly, and then titrate with the alum solution. Toward the end one must wait a few moments after each addition of the reagent that the precipitate may settle and allow the end reaction to be seen.

*Rapid Method for Phosphorus in Manufactured Iron and Ores.* Handy (*J. Anal and App. Chem.*, vi, 204). The determination of the acidity of the molybdate precipitate (*vid.* QUARTERLY, xiii., 289) is the chief feature of this process. The solutions used are:

*Standard NaOH.* Dissolve 15.4 gms. in 100 c.c. water, stir in saturated $Ba(OH)_2$ solution until no more precipitate of $BaCO_3$ forms. Filter at once and dilute to 2 litres.

*Standard $HNO_3$.* Make stock solution 200 c.c. of acid (Gr. 1.42) in 2 litres. For approximate standard dilute 200 c.c. of the stock solution to 2 litres.

These two solutions should be made to agree c.c. for c.c., and also had best be brought to a strength of 1 c.c. = 0.0002 gm. P.

Standardize by 0.1 gm. pure molybdate precipitate obtained from acidified ammonium or sodium phosphate, washed with 1 per cent. $HNO_3$ and thoroughly dried at 100°. It contains 1.63 per cent. P.

E. F. Wood's formula for the molybdate solution is recommended. As indicator 0.5 gm. phenolphthalein in 200 c.c. of 95 per cent. alcohol is used. Three drops for each titration.

The method is: Dissolve 2 gms. steel in a 12 oz. Erlenmeyer, in 75 c.c. $HNO_3$ (Gr. 1.13); add 15 c.c. $K_2Mn_2O_8$ solution (5 gms. per litre) to the boiling solution. Boil till the pink color disappears. Oxidation is complete if brown $MnO_2$ separates. High carbon irons may require more $K_2Mn_2O_8$. Remove momentarily from the heat—add about one-thirtieth gm. granulated sugar, and heat until the solution clears. Let cool for a few minutes and then add 13 c.c. ammonia (Gr. 0.90) pouring carefully down the side. Agitate until the ferric hydrate dissolves. Cool or heat to 85° C. Add 50 c.c. molybdate solution. Cork, wrap in a towel and shake five minutes. Filter immediately. Wash five times with 1 per cent. $HNO_3$, then five times with 1 per cent. $KNO_3$. Place filter and contents in the flask. Add 10 or 20 c.c. standard NaOH solution. Shake a few moments to dissolve the precipitate. Add 3 drops of the indicator and titrate back with standard $HNO_3$.

*Silica in Clay.* Archbutt (*J. S. C. Ind.*, xi., 215). One drying with acid after fusion with alkaline carbonates is insufficient to separate all $SiO_2$. Fusion with $KHSO_4$ leaves some $SiO_2$ in a soluble form. A method is described thus:

1. Strong ignition of 1 gm. of the finely powdered clay.
2. Fusion with 5 gms. of pure mixed carbonates.
3. Extraction with about 200 c.c. $H_2O$, acidifying with HCl in excess, and evaporating to dryness on the steam bath in porcelain, reducing the residue to small grains.
4. Heating the dish and dry residue in an air bath at 150° for an hour.
5. Dissolving in HCl and water, filtering and washing the silica.

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6. Evaporating the filtrate with 20 c.c. strong $H_2SO_4$ till fumes are evolved *very strongly*. The acid will fume before it is fully concentrated; the object is to concentrate fully.

7. Dissolving in HCl and water, filtering and washing the small amount of $SiO_2$.

8. Igniting the united precipitates at the highest temperature of the muffle until constant in weight, then volatilizing by the use of HFl with $H_2SO_4$ and igniting to constant weight. The $SiO_2$ is thus obtained by difference.

*Chloric Acid in Chlorates.* Gooch and Smith (*Am. J. Sci.* [3], xlii., 220). A solution containing KI, $Na_2HAsO_4$ and dilute $H_2SO_4$ is boiled until the liberated I is expelled. This is cooled, neutralized with NaOH, and after addition of $NaHCO_3$ is titrated with tenth normal iodine. The same amount of the solution is treated in the same manner together with the addition of a known quantity of the solution of chlorate to be analyzed. HI and $H_3AsO_4$ will not react on each other so long as a chlorate is present, so the comparison of the first titration with the second affords a means of calculating the proportion of chlorate present. McGowan (*J. Lond. Chem. Soc.*, lxi., 87) has tried Bunsen's method—decomposing by HCl, driving over the Cl into another flask, subsequently adding KI and titrating with this sulphate, and finds that Finkener's objection (low results) is due to the contact of the Cl vapors with the rubber or cork connections, especially the former. When the apparatus is constructed so that this is avoided the results are satisfactory.

*Possible New Element.* Richmond and Off (*Jour. Lond. Chem. Soc.*) in examining a new mineral in Egypt discovered what seems to be a new element, which they have named masrium. It resembles glucinum in many of its properties. Atomic weight 228.

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# BULLETIN OF ALUMNI AND COLLEGE NEWS.*

On June 6th the Trustees adopted for the government of the College a new and carefully revised body of statutes. A School of Pure Science is created on lines similar to those followed in the case of the Schools of Political Science and Philosophy.

The faculty is understood to be composed of the professors of the departments of Astronomy, Biology and Botany with such other professors as actually give instruction in pure science.

The following appointments have been made to take effect July 1, 1892.

Francis B. Crocker, E.M., to be Adjunct Professor of Electrical Engeering. (March 7, 1892.)

William Hallock, Ph.D., to be Adjunct Professor of Physics. (March 7, 1892.)

Robert Peele, E.M., to be Adjunct Professor of Mining. (February 1, 1892.)

M. I. Pupin, Ph.D., to be Adjunct Professor of Mechanics. (April 4, 1892.)

By the adoption of the new statutes the University Council ceases to be merely advisory, and becomes the chief legislative body of the University. The old Board of the College is succeeded by the Faculty of Arts, which will hereafter be made up of the heads of eighteen departments represented in the curriculum and such other professors as are actually engaged in giving instruction to the Freshman, Sophomore, or Junior classes.

The erection of a small observatory will be at once begun upon the new site at Bloomingdale. This observatory will be completed by August 1st, and will contain a very solid pier, upon which will be mounted the new zenith telescope, now being made for the College by Wanschaff, of Berlin. This instrument, which will be ready by September, is one of a pair of instruments exactly alike. The other is to be mounted at the Royal Observatory of Capodimonte, near Naples, by order of the Italian government. With these two instruments, precisely similar, simultaneous observations will be undertaken for the purpose of securing a very accurate determination of the variation of terrestrial latitudes, recently discovered in Germany. Exceptional advantages are offered by the circumstance that the two observatories

* Condensed from University Bulletin No. III. and other circulars.

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are situated upon the same parallel of latitude, very nearly. It is confidently expected that this advantageous condition, which has not been realized in any of the series of observations so far undertaken, will lead to results of very high interest. The New York observations will be made by Professor Rees and Mr. Jacoby; those at the Italian observatory, by M. Fergola. It is expected that work will be commenced by October 1st, at both stations.

The Trustees have purchased from M. Struve, former director of the great National Observatory at Pulkowa, Russia, his fine library of astronomical and physical works. This library contains 4361 bound and unbound books and 3056 pamphlets. M. Struve also offers to give to the collection all the works he may receive up to the time of his death.

The new Department of Biology will open with the fall term of the College, October 3, 1892.

The course in animal biology is designed to extend over four years, including two years of undergraduate study in preparation for the bachelor's degree and two years of graduate study and research in preparation for the degree of doctor of philosophy.

All the fundamental instruction and practical training in technique will be given in the two undergraduate courses, during both the first and second terms, four hours a week:

I. ELEMENTARY BIOLOGY. Lectures and laboratory work.

II. ADVANCED BIOLOGY. Lectures and laboratory work.

A general course will be given to second-year student in the School of Mines, consisting of lectures and demonstrations, without practical work, as follows:

III. GENERAL ZOOLOGY. First and second terms, 2 hours a week.

The following special course will be offered to seniors preparing for medicine or studying physiological psychology:

IV. COMPARATIVE NEUROLOGY. First term, 2 hours a week.

The undergraduate courses are of a liberal character and do not include highly specialized work. The elementary biology is designed for an introduction to organic chemistry, geology, palæontology, psychology, as well as to botany, physiology, and advanced biology.

The advanced biology is somewhat more special and will be adapted for students intending to make biology, palæontology, or medicine their professional study.

Students entering these courses must have first received preliminary training equivalent to the above, in order to enable them to work independently.

The first year's course should include at least two days of outside laboratory work a week in some cognate minor subject, as botany, organic chemistry, palæontology, or geology. The second year's course should include at least one day of such work.

A special feature of the department will be a series of lectures of a semi-popular character for those who desire to keep abreast of the later researches in different branches of biology, without entering the full advanced instruction. The subjects for 1892–3 are:

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PROF. OSBORN.—History of the Theories of Evolution and Heredity.
PROF. WILSON.—The Biology of the Cell.
DR. DEAN.—The Structure and Classification of the Fishes.

The Trustees of the College have subscribed for an investigator's table, during the summer course of the Marine Biological Laboratory at Wood's Holl, Mass., in which excellent opportunities for research and collection are offered.

Pending the construction of the permanent biological laboratory, the regular courses for the coming year will be conducted in the third floor of the north wing of the College of Physicians and Surgeons, entrance upon West Sixtieth Street, near Ninth Avenue. The rooms provided here are general and advanced laboratories, lecture-room, special staff room, reading-room and research rooms.

## SYNOPSIS OF COURSES.

### COURSES FOR THE DEGREE OF BACHELOR OF ARTS.

Course I.—ELEMENTARY BIOLOGY.

Juniors, 4 hours (2 afternoons) a week.
General structure and functions of the lower and higher forms of animal life, lectures and laboratory work, including an introduction to:
Animal morphology: structure of nervous, muscular, digestive and other systems.
Animal histology: cellular basis of life.
Animal physiology: main functions of life.
Zoology: classification, distribution, and relations of animals to each other.
Evolution and heredity: introductory.

Course II.—ADVANCED BIOLOGY.

Seniors, 4 hours (2 afternoons) a week.
Embryology, or development of individual life.
Same subjects as in Course I., treated in a more thorough and special manner.
A short original thesis upon some simple problem in morphology or embryology, for graduation.

Course III.—GENERAL ZOOLOGY.

Second year, School of Mines, 2 hours a week, first and second terms.

Course IV.—COMPARATIVE NEUROLOGY.

Seniors, 2 hours (1 afternoon) a week.
Brain and nervous system in the lower and higher animals, general structure (introduction to physiological psychology).

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COURSES FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Course V.—ADVANCED MORPHOLOGY.
" VI.—ADVANCED EMBRYOLOGY.
" VII.—ADVANCED ZOOLOGY.
" VIII.—VERTEBRATE PALÆONTOLOGY (1893–94).
" IX.—COMPARATIVE NEUROLOGY (as above, with laboratory work additional).
" X.—EVOLUTION AND HEREDITY.
Original doctor's thesis in one of the above branches.

PROPOSED COURSE BY PROFESSOR J. G. CURTIS.

Course XI.—ELEMENTARY AND ADVANCED PHILOSOPHY.

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**ELEVENTH YEAR Begins October 3d, 1892.**

### SUMMER SESSION.

A Summer Session to prepare students in Mathematics, Sciences, Languages, etc., for entrance to the School of Mines, and for advanced standing in **ELECTRICAL ENGINEERING**, and other courses, begins August 15, 1892.

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Four hundred Students of Columbia School of Mines have been instructed in the Woodbridge School.

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